USING GAMES FOR LEARNING – DEVELOPING A METHODOLOGICAL APPROACH

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Abstract

This thesis presents an investigation into the use of computer games technology and techniques in the creation of a games-based learning environment. This could support the principle of enhancing student learning through the engagement and motivation evident in computer games, with the added benefits of reinforcement through reuse, and socialisation. An additional benefit of a games approach is the natural support for constructivist pedagogy.

The research commenced with a survey of existing learning technology and games for learning. From this it was clear that there are issues with current virtual learning environments, and the investigation showed that these are unsuited to support games-based learning. It was also clear that a number of existing games for learning built for purpose have been successful, but there are issues over reusability. The conclusion from the survey and other background research done for this thesis was that the development of a learning environment utilising a games engine could be an appropriate basis for the creation and configuration of reusable integrated games for learning. The selection of a games engine for this development meant that a consideration of extending the capability of the engine to support a learning environment was required. This led to an investigation of adding full assessment capabilities and an initial investigation were carried out which showed this to be feasible but more investigation of online assessment techniques are required.

Utilising the games engine as a learning environment a series of studies considering the integration of learning material into computer games were carried out. The rationale for these studies was to investigate the effectiveness of different models of integration and reusability of games configured in this way. Following a user evaluation and analysis a further study extending the capability of one particular approach, that of embedding learning material into a pre-authored game, demonstrated the outcomes that the research was seeking. From this a methodological approach for the design of a games based learning environment and a conceptual design for the authoring of an embedding approach to integrating learning material within a games context was described, and finally the contribution to the body of knowledge was clarified.

Acknowledgements

First, I would like to thank my supervisor Prof. Lachlan M. MacKinnon, for his continuous support in the work for the Ph.D. Lachlan is a friend and mentor and was nearly always there to listen and to give advice. Though we rarely where in the same country, he was always available via one or more forms of electronic communication, phone, e-mail or video chat. He spend many a long evening trying to make me understand how to write academic papers, had confidence in me when I doubted myself, and brought out the good ideas in me. He taught me how to ask questions and express my ideas both in written and oral form. For all his assistance in the completion of this thesis and the papers preceding it as well as the research that lies behind all, I owe him a great gratitude.

I would also like to thank my second supervisor Dr Henry Fortuna, he was an excellent discussion partner as an contrast to Lachlan. His input to the development of the games for the studies was most welcome. His different view on the research and his input to both content and structure of the thesis made quite a difference.

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1 Introduction

This research was initiated by an interest in Virtual learning environments (VLE) and e-learning in general. The author was also involved with the Buskerud University College e-learning committee, which from 1998 onwards was responsible for the introduction of a VLE for the whole of the College, and then running the system and encouraging and developing the use of the VLE to provide support to students both on and off campus.

One problem that became apparent with students working with the VLE and e-learning was that once the initial novelty of the "new toy" had worn off it was difficult to motivate them and make them reengage with the learning material. Whereas the same students, when playing computer games, did not lack any motivation and were willing to take on challenges and work hard at solving them. The question that then begs to be asked is "if the computer games industry can motivate and engage the students to solve apparently pointless challenges, why are we as educators not able to do the same?"

The starting point was to investigate what had been done previously in e-learning in virtual learning environments, and what investigation there had been into the current lack of interest in engineering and hard technical subjects. People of all ages are very interested in technical gadgets and the use of technology in general, but tend to shy away from the actual technical details and the inner workings of the latest gadgets. The initial aim of this investigation was to discover what elements from games could be integrated into the VLE and e-learning to make it more motivating and engaging,

what could be done to make the students keep trying and be willing to put in the effort required to learn difficult things.

One of the key concepts identified early on was that of constructivist learning, and the fact that the underpinning models for games are inherently constructivist. There is a certain element of drill and practice in computer games, and as the investigation progressed it was identified that many of the games created specifically for learning had this drill and practice or rote learning as their sole learning model. However, drill and practice models are only evident at the early stages in large games, when the player has to learn how the world works and how to interact with it. Once the initial phase of the game is complete the nature of these games change and players are free to explore the environment and continue to build their mental model of how the game world works and the content within it. Freedom is often limited in the early stages and there will be ample support offered to the player as they move through the game, but once a player has passed these initial stages this support is reduced and eventually withdrawn. In addition the gaming format lends itself to support the known advantages of narrative from oral traditions and fits with the younger generation's interest in current trends in the entertainment industry.

When starting to consider these large computer games in terms of a constructivist pedagogy the similarity of the games approach quickly becomes apparent. The notions of letting learners explore the material with support, usually referred to as scaffolding, that then fades as the students become more familiar with the material is identical. The need and use of social aspects in the online games are equivalent to the important social aspects of learning. Social aspects of games can be used to learn the

game, as part of a more general level of social activity, whereas the social aspects of learning are explicitly used to support and contextualise learning.

The decision to investigate a game-based approach to the development of e-learning was based on several studies that have shown the significance of using computer games in education. In particular, Henderson [1] published a study showing that playing a recreational video game provided beneficial informal educative experiences, even when used only over a short period of time. This study provides support for the cognitive worth of playing games, and it also contradicts the popular opinion by confirming that recreational video games is a significant cognitive artefact of youth culture. Building on from these studies, the research described in this thesis was initiated by a survey of current state-of-the art support for lifelong learning[2], a key element of that investigation being the different techniques to improve learning and retention through engagement of the student. On the basis of the outcomes of that survey, and the other elements described in this Introduction, a research plan was developed to investigate the hypothesis "It is both feasible and effective to develop games-based learning activities using existing VLE and learning object technologies, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play."

1.1 Content of the following chapters

Chapter Two aims to provide a background and overview of the state of art in the topic areas of distance education, virtual and asynchronous learning environments. There is also an investigation into the use of games for learning and how different pedagogical models fit into current and future use of virtual environments for learning. The background is focused on the use of e-learning in connection with

engineering education and "lifelong learning", and aims to identify the gaps in the current body of research. Most of the background was published as "A survey of current state of the art support for lifelong learning"[2] at ITHET in 2005. A follow up to this work and the work on creating a design for a games based environment, entitled "Games-based support for lifelong learning"[3] was published at REV in 2007

Chapter Three describes a conceptual design for a games-based learning environment. The design covers all aspects of the functionality and features that a fully implemented environment must support.

- Maintain the engaging nature of games.
- Use of narrative elements and storytelling in learning.
- Utilise the natural interest from the younger generation.
- Learning by doing.
- Social aspects of learning and how assessment and reassessment can be handled.

The conceptual design was published as "Exploitation of games and virtual environments for e-learning"[4] at ITHET 2006, and in part with an emphasis on supporting lifelong learning and remote practical work as "Games based support for lifelong learning"[3] at REV in 2007. The chapter gives an overview of the different development platforms that were considered as a basis for the games-based virtual learning environment. The chapter also describes a scenario for future development and describes the setup, usage of the tools, and some of the work done for the development of the prototypes.

Chapter Four covers an investigation into a potential model for automated assessment within the environment: "student-created narrative-based assessment". The work addressed the desire to have an assessment method that can be used as a text-based format within a computer game with immediate feedback to the user. The work was published as "Student-created Narrative-based Assessment"[5] at eLearn in 2006, and the results from a trial run using two widely-available plagiarism detections tools have been published as "A consideration of the use of plagiarism tools for automated student assessment"[6] in IEEE Transaction on Education, 2008.

Chapters Five through Eight describe different prototypes that are all designed to test the viability of modelling learning material as quests within a games-based environment, and to test various methods for incorporating this learning material.

Chapter Five describes a study where the learning material is integrated with the game elements by layering the learning material on top of the game. The game is designed to encourage the students to learn about and verify their knowledge of the Java programming language with a particular focus on the use of methods in Java. The simple solution of layering the learning material on top of the game means that the quests and other game-play bear no relation to methods in Java or programming at all. The experiment was run with students in spring 2007. The outcome of the study were published as "Prototyping a Games-Based Environment for Learning"[7] at E-learn 2008, in Las Vegas USA.

The study in Chapter Six describes a game design where the learning material is embedded into quests as part of an overall game designed to encourage the students to learn about and test their knowledge of the C++ programming language. The study was run in the spring of 2008 jointly in Norway and Scotland. The results from this study were published as "Prototyping Games-Based Environments for learning C++ programming " [8] at HCI Educators 2009, in Dundee UK.

The study in Chapter Seven is based on an extrinsic bespoke game development, i.e. the game is constructed purely around the learning material with no gaming elements imported from any existing game. The aim of the game is to encourage the students to learn about and test their knowledge of analogue electrics, in particular the design of a stable power supply. The study was run in the autumn of 2008. The design and a preview of the study were published as "Games-based environment for e-learning in analogue electronics"[9] at ICL in 2008. The findings of the study has also subsequently been published as "Computer-based Role Playing Game Environment for analogue electronics"[10] in the International Journal of Online Engineering 2009.

The study in Chapter Eight is based on an intrinsic bespoke game development, i.e. the game is constructed from scratch but created with no explicit learning content, the game works as a game for learning only in combination with the accompanying lectures. The aim of the game is to encourage the students to learn about algorithms for the routing of data in a network. It was run with students in Spring 2008, and was published as "A Blended Learning Exercise using a Computer Game based on Abstract Learning Materials"[11] in ICL 2009 and will be published as "A computer game modelling routing in computer networks as abstract learning material in a

blended learning environment"[12] in International Journal of Emerging Technologies in Learning, in print, November 2009.

In Chapter Nine there is an analysis of the results gained from the study described in Chapters Five through Eight. This analysis determined that a new study with the game utilising the embedding approach to integrate the learning material and games elements, but enriched with more game elements and a generally richer environment in all aspects, should be undertaken. This richer environment, though still very limited, would be more in line with what would be found in an equivalent commercial game.

Chapter Ten follows from the analysis of the first set of games. An study was designed to see if a game that has been enriched with more game elements, within a generally richer environment, would create increased levels of the desired engagement, resulting in some elements of reuse and socialisation. The study builds on the game with embedded learning content first described in Chapter Six.

Chapter Eleven describes a methodology for effectively developing games with learning content for one or multiple target audiences, based on the design and outcomes of the studies.

Chapter Twelve presents the conclusions of the research, relative to the original hypothesis and goals, the contribution made to the body of knowledge, and the further work identified as a result of this research.

Appendix A gives several Python code templates for creating items, recipes, dialogue for NPC (Non Player Characters) and how to create an NPC.

Appendix B contains the pre and post questionnaires used with the students for all prototypes both in Norway and Scotland

Appendix C gives an overview of the scripts and some of the data logged by the systems during game-play.

2 Literature review

This chapter aims to provide an overview of the state of art in the areas of e-learning, virtual and asynchronous learning environments. There is also an investigation into the use of games for learning and how different pedagogical models fits into current and future use of virtual environments for learning. The background is focused on the use of e-learning in connection with engineering education and "life long learning", and aims to identify the gaps in the current body of research. The main focus has been on models that are developed from the constructivist tradition, based on the notion that learners actively construct their own understanding and knowledge from their experiences.

The chapter also contains a review of the use of computer games for learning and the different aspects of computer games that can be used in education, this is focused on the elements that make computer games engaging and motivating. The area of social interaction online and particularly in games is also investigated, with the aim of use this as part of the support for the important social aspects of learning.

Most of the background was published as "A survey of current state of the art support for lifelong learning"[2] at ITHET in 2005. A follow up to this work and the work on creating a design for a games based environment the "Games based support for lifelong learning"[3] was published at REV in 2007

2.1 Overview

The development of new models, methods and tools to support distance learning, in particular synchronous learning environments and "Virtual classrooms", has been

significant over the last ten to fifteen years. During this period many new standards have been defined, with those related to learning objects, such as IEEE LOM[13] and IMS[14], having a major influence on this development.

Over the last decade the use of internet based learning has seen a significant increase. As the technology is becoming more commonplace and the average learner has a computer available to support them in the tasks of learning, universities and other educational institutions are moving into this market. The traditional role of educators in higher education is changing, with many being pressurised to get involved in the online "revolution".

At the same time as this technological change influences everybody's lives, there is also a shift in the theories used to underpin the development of learning materials. There are a number of different pedagogical models proposed to support e-learning[15], ranging across a spectrum from objectivist to constructivist models. It has become a common belief that the best model for teaching in higher education is the constructivist model[16, 17].

When creating learning material that follows the constructivist tradition the focus for the author of the learning material is on creating material that focuses on the activities performed by the students. Frameworks like the one described by Ferreira, MacKinnon, Ra[18] et al. are a huge help when constructing the material in this way. Another challenge for the authors of learning materials, in addition to the focus on getting the learner to perform activities, is that there must also be a sufficient amount

of material constructed, and presented in such a fashion as to allow the learner to explore and navigate freely.

Most people benefit from a social community setting when they are involved in learning activities. Having others to discuss their experiences and difficulties with or to try out ideas is helpful. This social community is present in lectures and tutorials. This is very strong in the Nordic-countries traditional view of education where there is often a strong urge for the learners to meet up with each other and with the instructor. The view is not that the only learning that can occur is face to face, but rather that social activities are an important and significant part of the process. As Mayes[19] puts it: "Lectures are occasions where the individual is confirmed as a member of a learning community." One of the challenges in online learning is to create this feeling of belonging to a community.

Rovai[20] presents a study that shows

> *"online graduate students can feel connected to their virtual classroom community, students with stronger sense of community tend to possess greater perceived levels of cognitive learning,"*

This may be taken as an indication that it is possible to accomplish the all important social interaction and sense of belonging in an online format. This will be discussed further in the section 2.9 on online games and learning

The use of narrative as a means of connecting up separate elements and as a memory aid is well known, and storytelling is by many referred to as "the original form of

teaching". Storytelling is one of the most effective techniques for conveying information in a compelling and memorable way. Many cultures have long traditions for telling stories when wanting people to remember a message. The trick is to provide just the right amount of suspense and excitement into the story so the audience is motivated to keep listening. A story can in this way be a powerful motivator to keep going, and find out what happens next, thereby helping the learners to complete a course.

2.2 Constructivism

There are a number of different pedagogical models proposed to support learning. The traditional focus has been on an objectivist, also referred to as instructivist, model. This model is based on the belief that knowledge should be transferred/transmitted from an all knowing source (the instructor) to a receptive target (the student).[21] In this model knowledge is something that exists independently of the instructor and is not subject to contextual interpretation, and understanding is based on assimilating this pre-existing knowledge.

The constructivist model is founded in the work of Vygotsky, Piaget and others, and is based on the notion that students actively construct their own meaning and knowledge from their experiences. The notion of discovery learning[22] is often used in this context.

2.2.1 Constructivism and deep knowledge

The constructivist model as stated above is based on the notion that students actively construct their own understanding, meaning and knowledge from their experiences. In this model the instructor has the role of guiding the students to create their own

knowledge through learning activities. Learning must then focus on thinking and understanding, rather than on rote memorisation.

One of the points made in constructivism is to get the students involved in the process, and give the tutor the role of facilitating and supporting learning. Most students will, after some initial misgivings, elect to follow the active learning route and get involved in the learning process. The rationale for this is that it is simply more enjoyable. It can be argued that a constructivist model will be more successful because:

> "Education works best when it concentrates on thinking and understanding, rather than on rote memorization. Constructivism concentrates on learning how to think and understand."[23]

Constructivist learning also has the advantage of being transferable.[24] In constructivist based learning, students learn and understand principles that they can take with them to other learning settings. Constructivism gives students ownership of what they learn, since learning is based on students' explorations and active participation.

The theoretical argument for constructivism is that deep knowledge and long-lasting knowledge is more likely to arise from constructivist learning environments. The perceived benefits of a constructivist learning environment include absorption and synthesis of facts, linking the knowledge of facts with understanding of other knowledge domains, the enhancement of collaborative/cooperative skills and time.[25, 26]

Constructivism promotes social and communication skills by creating a learning environment that emphasizes collaboration and exchange of ideas. As part of this, students must learn how to articulate their ideas clearly as well as to collaborate on tasks effectively by sharing in group projects. The challenge of doing this in an e-learning setting is greater than in a face to face setting. This is one of many challenges facing the educators involved in e-learning. .

The argument is that by grounding learning activities in an authentic, real-world context, constructivism stimulates and engages students, and at the same time promote communication and social learning.

2.2.2 Revisiting

The idea that learners should revisit and repeat the material multiple times are probably as old as learning. In skill based learning the repetition is obvious, the more you try the better you get. In learning situations where understanding is required repetition and revisiting is just as fundamental. The technique is used through all levels of the education system. Pupils or students do assignment after assignment of similar type to increase their skill and understanding in a subject area. The theoretical background for this approach is outlined by Vygotsky[27] and is part of his "Zone of proximal development"(ZPD).

Tharp and Gallimore[28] presents a four-stage model incorporating ZPD as the first two stages. It is the ZPD in this model i.e. the first two stages that are of particular interest.

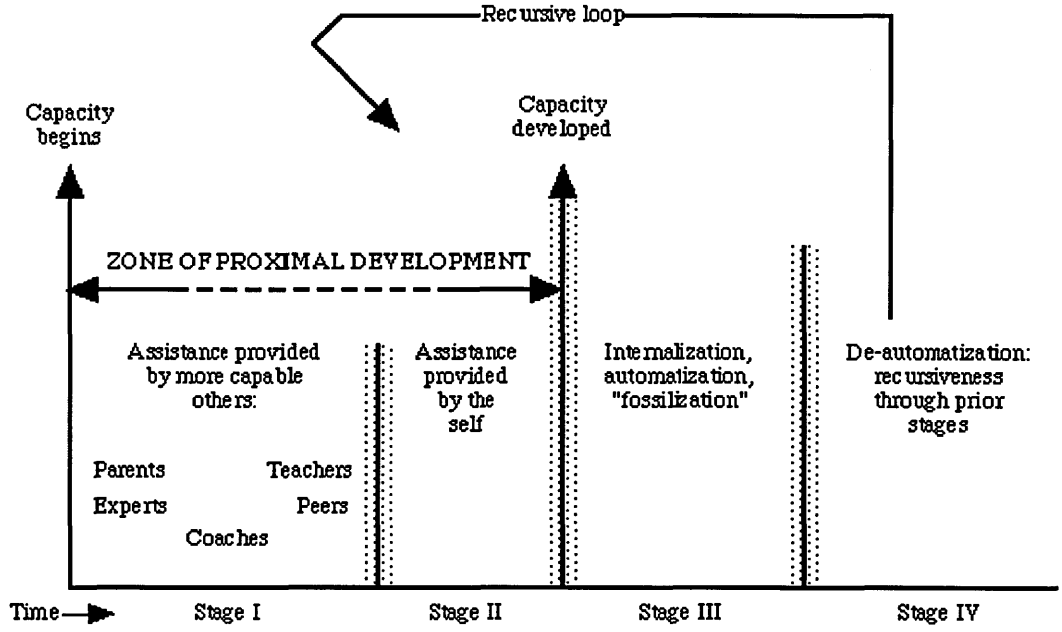

Figure 2-1 Four-Stage Model incorporating of ZPD[28]

Stage 1 is the initial stage where learners are presented with new material and needs help to be able to progress, this assistance can take many forms, but is often characterised by being in a social setting. As stated in[27]:

> *"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers"*

Stage 2 is the period where the learners, alone or in groups, revisit the material and gain understanding. This period is important so that the learner is able to gain an understanding of the material and is able to build on this learning in the future. This period is when the learner goes through, revisits and reengages with the learning material that has been introduced previously.

2.2.3 Scaffolding

Scaffolding is a term used to describe the support given to a student when that student is not ready to do a particular task on their own. Scaffolding techniques, first introduced by Bruner in the late 1950 but first described in 1986[29], is based on the ideas of Vygotsky. The technique is based on guiding and directing the students and initially gives them a well defined task and offers plenty of support. As the students progress through the subject area the close support fades and the students are increasingly given tasks that requires them to take control and work increasingly independent. Scaffolding only makes sense if the support offered is faded into the background so that learners take over the responsibility for themselves, from there comes the term scaffolding and fading. The use of scaffolding to guide and direct students aims to strike a balance between control and freedom.

Different scaffolding techniques are presented by for example Wood et.al[29]. and Boyle[30]. They all focus on the approach that authors must create a scaffolding to assist the learner. This scaffolding will be gradually removed as the learner becomes a more independent problem solver.

Boyle[31] identifies three distinct scaffolding strategies. The first strategy is to ground the learning experience in a familiar setting. This can be done simply by using familiar terms, making the background a familiar picture or set a familiar scene for the learning to occur in. The second scaffolding strategy involves bridging the gap between familiar representations and new representation. The bridging occurs by exposing the student to familiar and new representations simultaneously. This technique can for example be used with a textual explanation and a mathematical

expression, thereby exposing the student to a familiar and a new representation of the same formula. The third and last strategy for scaffolding is based on the familiar technique of immediate feedback to the student. The feedback will allow the student to test hypotheses and/or change and refine ideas to fit the situation, or system, they find themselves in.

2.2.4 Learning styles and multimodality

Learning styles are the various ways or approaches a person takes to learning that will help that individual to learn best. It is the common belief that most people prefer a particular method of gathering, and processing stimuli and/or information. There are many different models to represent a learner's learning style e.g. [32-35]. Several of these models do in essence divide learners into visual vs. textual and overview vs. details.

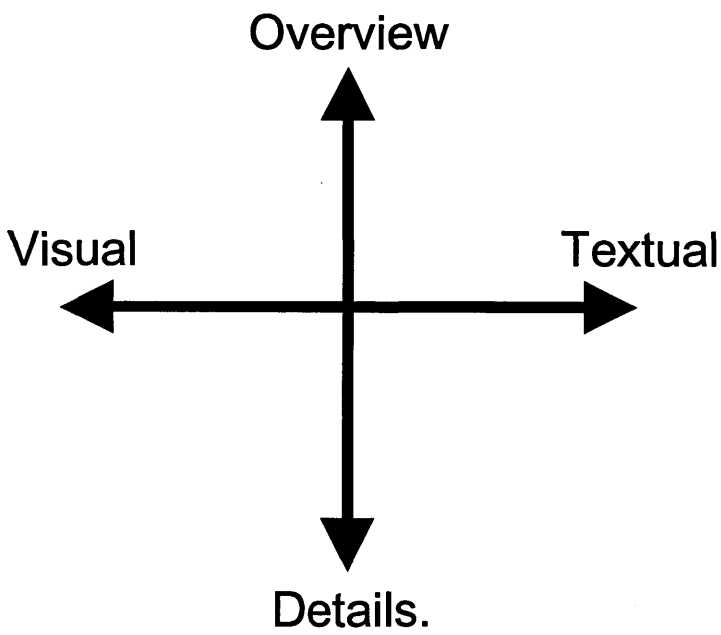

Figure 2-2 Learning styles

Visual vs. textual measures how much particular learners prefer to get information presented as pictures, figures or video vs. in a traditional textual form. The measurement of details vs. overview indicates if a learner prefers to be presented with all details then build a complete understanding by themselves vs. if an introduction of the major points and then revisit the topics several times revealing more and more details.

Creating a learning environment requires the authors to support all different types of learners with their different learning styles. This need to support different learners requires the inclusion of information in multiple formats and available for the learner to explore either from looking at the big picture and going into details or diving straight into the details of each particular sub-topic.

Research has shown that what is needed is to support multimodality, which is the delivery of multiple formats through one information channel.[36] Multimodality will also act as an aid in reinforcement, because one piece of information is available in different forms each reinforcing and aiding in the understanding of the information.

The act of supporting different modes of learning suited to a particular person's learning style requires the development of multiple separate modes for each different learning style. The use of this method, offering one mode of learning tailored to a particular user, has several drawbacks: First and foremost that it is difficult to know what mode to offer the user, and secondly the added bonus of reinforcement given by multimodal representation is lost.

2.2.5 Assessment

The traditional focus on assessment has been on the final exam. Students will naturally try to guess the exam questions and will make this the focus for the learning rather than the learning objectives. If the assessment is poorly focused the students will underestimate requirements and try to get by with low-level learning strategies. The most important factor in creating a good assessment system is that the assessment must be designed into the learning process, this is well documented[21, 37]. Additionally it is important that the assessment must be used to test that the desired learning has taken place, and not check that the student has learned only the desired facts.

2.2.5.1 Clear goals

The importance of setting a clear goal for students is paramount. Once the goals are set, they help to keep students and content developers/educators focused on the items that were identified as important. It is equally important to match the learning goals with the assessment, described above.[21]

One of the main difficulties students have is being able to separate the information that they really need to know from all the other less important information that is thrown at them. This is particularly important in an environment where the students are exploring. The content developers and educators must be aware of the dangers and make the environment as free of extraneous content as possible for the students. The scaffolding need to support and aid the student to focus on setting clear goals and form a picture of what the expectations are and where to focus their time and attention. Goals will give students something to strive for. This is important because it

helps to motivate the student and it also provides a sense of accomplishment when goals are reached. The continuous exposure to tasks is a strong feature in various forms of entertainment particularly the computer games industry has been adept at using this as one of the motivating factors for their players.

2.2.5.2 Constructivism and assessment

The theoretical argument for constructivism is that deep knowledge and long-lasting knowledge is more likely to arise from constructivist learning environments[38] and the use of multiple cognitive channels. The body of evidence for this is convincing, but only where sufficient periods of time is allowed to permit learning and reflection, and appropriate assessment is carried out timeously to embed and reinforce learning.

Expectations and outcomes are different in a constructivist learning environment than those found in the traditional classroom. Therefore, testing procedures must be redesigned to compensate for the expanded knowledge base that the students are developing. If insufficient time is allowed to pass and we too quickly try to assess the knowledge the students have acquired, the results will be unsatisfactory and students dissatisfied with the results. Findings by McKenna and Leycook[39] show that for short learning periods with tests performed immediately after the learning period, instructivist models will provide better results and make for more satisfied students.

> *"Students using the instructivist resource improved most in relation to this previous class average mark. In terms of attitude, students also preferred to use the instructivist environment, or the mixture of instructivist and constructivist, rather than relying solely on the constructivist."* [39]

They go on to note that:

"the instructivist artefact offered clear structure and instructions as well as familiarity, the constructivist environment almost certainly required the user to make more effort" [39]

However, they also note:

"those using the constructivist artefact coped with the more complex material (such as signal to noise ratio) slightly better." [39]

2.2.6 Narrative based assessment

Educators generally have been consistent in arguing that higher education should be about encouraging students to take a deep approach to their studies, i.e. they should learn the material and not just memorise it so they can retell in exams. One of the major challenges of this is that even if the teaching of the students does take a deep approach it does not necessarily lead to the desired learning outcomes. Assessment, as so clearly shown by [21, 40], drives the learning process and over-rides practically every other aspect of curriculum design, students will be guided by the assessment and not by what they are told. The general understanding is in order to get the best learning and most proper assessment, the assessment should be designed into the system and be an integral part of the learning process. The importance of having the assessment as an integral part and not something added just at the end is well documented.[21, 37]

Assessment has two goals, covered by formative and summative assessment. Formative assessment is designed to aid the learning process, it is a mechanism to encourage student reflection by the means of synthesis of their existing understanding and then reflection on the feedback they receive on that understanding. The

summative assessment evaluates the student's knowledge in the area. It is important that summative assessment is included as part of the course, not solely at the end. From definition by The American Association for Higher Education, November 1995 *"Assessment is an on-going process aimed at understanding and improving student learning."* It is important to remember that learning material must contain both formative and summative assessment.

Traditional assessment is based on students producing essays on demand. Producing a well written text will for most people require several revisions and consequently the time to make them. In addition the added stress of an exam situation has an adverse effect on the student's ability to produce a well written text. The outcome of this is that the student will fall back on knowledge-telling strategies and will not demonstrate the full extent of their knowledge. Cho[41] in his paper "Assessing writing: Are we bound by only one method?" asks the question

> *"How realistic and fair is it, then, to expect somebody to draft a well-organized essay in less than an hour on a topic that the writer may or may not have thought about before?" [41].*

According to Scardamalia and Bereiter[42], the most influential model of the cognitive processes in writing is the one proposed by Hayes and Flower in 1980. This model describes three cognitive processes: planning, translating, and reviewing. Their main contribution to this model was showing that these cognitive processes are not necessarily strictly sequential rather, these processes may interact recursively with one another. In addition to this Scardamalia and Bereiter divides the method selected by individual writers into two major categories: knowledge telling and knowledge

transformation. The knowledge telling process is when the memory is searched for content relevant to the topic and whatever comes to mind is written down. Knowledge transforming process is a more complex process in which goals are incorporated into the planning process and only content relevant to both the topic and the goals is written down, this process does also include multiple revisions of the produced text. A more detailed description can be found in "Assessment of Planning, Translating, and Revising in Junior High Writers"[43]

Research by Powers and Fowler[44] have shown that even small increases of time at written tests can give significant improvements in test score. The same results have been reported by others, in addition to the results time constraint will also influence the writing style. The students need to be given ample time to prepare and their writing. This is important as the aim is not that the students resorts to knowledge-telling strategies as described by Bereiter and Scardamalias[42] model, the aim is for the students anchored in the constructivist model, transforming the knowledge and making it their own. The strategy of knowledge-telling is a low level strategy that is triggered by imminent deadlines and other stressful factors. The distinction between knowledge telling strategies and knowledge transformation strategies are similar to the distinction in learning between deep and shallow learning, described by Marton and Saljo [38].

2.3 Current use of e-learning

Most e-learning today is online and takes place through a web browser but e-learning or electronic learning is a term that includes all types of technology-enhanced learning, where technology is used to support the learning. Usually the medium used to transfer the information to a computer today is online but also CD-Rom or, video-

based learning activities are considered as e-learning. As Thomas De Praetere states[45]: *When an activity belongs to "e-" but not to "learning" or belongs to "learning" but not to "e-", it should not be considered as e-learning"*

The use of virtual learning environments in higher education has shown significant growth over the last few years. This presents challenges in a variety of ways: How to provide effective educational materials within virtual learning environments (VLE)? How to adapt an appropriate teaching style and pedagogy?

Below is a short summary of e-learning and the different tools and products in use. There is also a section on the most used (at least in many educational institutions) form of e-learning: Blended learning, the combination of electronic and face to face learning. The section rounds of with research that has been looking into the question of "Is the work that goes into creating interactive learning material worth it?"

2.3.1 Short summary of e-learning

In "E-learning: Is it the e or the learning that matters?" Hamid[46] gives a good overview and summary of what is referred to as the Pedagogical dimensions of e-learning. There is a need for a constructivist approach, where all knowledge is based on previous knowledge and the aim is to provide structure and not just a document dump. A constructivist approach does also give us an inbuilt reflective approach. The learning should be self-directed, to give the students responsibility, clearly define the goals and provide tools to help achieve this goal and verify that the students moves in the correct direction. E-learning should also evoke intrinsic motivation. Elements like lack of technical skill, isolation are all frustrating elements and should be removed or minimised. A support for individual learning style and support the individual, so

students spend the time they personally need before moving on. It is preferred if the material can be tailored to the individual student. Make sure to not make the student a passive learner. And lastly support learning as both a private and social activity. E-learning can accommodate both the private and the social settings and provides information to search and sort out discussions board and collaborative tasks.

2.3.2 E-learning tools and products

E-learning authoring tools are software applications that allow the presentation of course material, sometimes along with animations, audio or video. These tools also include the capability to provide interactive tests or exams and to save the grades for the instructor.

During the latter part of the 1990's tremendous effort was put into the development of new tools for authoring both learning material and web material in general. The last few years have not seen as many new tools coming to the market, many of the smaller companies and tools have disappeared, and efforts have predominantly been centred on further development of existing tools.

At the basic level, Microsoft PowerPoint[47], Macromedia Dreamweaver[48], Breeze[49] and Flash[50] can be used to author e-learning material. Macromedia Authorware, Director, and SumTotal Toolbook II all offer a higher level of functionality and are especially used in Computer-Based Training (CBT) applications. There are also numerous other proprietary authoring tools available, many including course management capabilities.

Tools that include course management are referred to as Learning Management Systems (LMS). LMS is a broad term that is used for a wide range of systems that organize and provide access to online learning services for students, educators, and administrators. These services usually include access control, provision of learning content, communication tools, and administration of user groups. Other terms that are often used as synonyms for LMS are learning platform and virtual learning environment (VLE). There are many commercially available VLE, the biggest ones were WebCT[51] and Blackboard[52] until Blackboard bought WebCT. There are also a number of open source or free to use tools like Moodle[53] and Sakai[54]. There has been a proliferation of these tools but they are now converging into a few larger ones that are commercially supported.

When it comes to VLE with inbuilt explicit support for pedagogy, the number of available systems is much more limited. Govindasamy[55] presents an e-learning tool that is supposed to contain inbuilt pedagogical models, unfortunately the system is not available for testing.

2.3.3 Blended learning

The most common definition of blended learning is combination of both online and face-to-face learning. A full definition of blended learning according to Graham[56] includes that blended learning is: A mix of different learning environments, or instructional modalities, or instructional methods. As Graham also [56] points out :

> *"Both of these [last two] positions suffer from the problem that they define BL so broadly that they encompass virtually all learning systems."*

So blended learning is the combination of instruction from two historically separate models of teaching and learning: traditional face-to-face learning and distributed learning. [56]

The first start for many instructors when moving into the e-learning domain is to start with material that supports traditional face to face activities. Research show that the primary use of VLE for many staff is for course administration purposes[57, 58], the educators tend not to use the full pedagogical potential of the web-based system. Even so the possible potential of VLE tools to increase course administration efficiency and enhance learning in a traditional setting is important. For example there is considerable potential in the use of discussion boards, which can be used to increase the overall involvement of students in the learning process. The bulk of material will often not even be related to the material covered but will be administrative in nature.

The challenge with discussions boards is to get the majority of learners involved. Caspi, Gorsky and Chajut[59] carried out an analysis of discussion groups connected to a course. They looked at the number of posts by the students and instructors and the number of replays to the messages. Their finding where that:

- Most students never post (at least more than once or twice)
- 75% of threads started by the instructor remained unanswered

Even so, discussion boards allow learners more control over what they can say and when they say it than in a traditional lecture. They contribute more messages in discussion boards than in a traditional classroom setting. Over half of the students felt that they learned a tremendous amount by exchanging information and sharing

experiences with their peers. This supports the notion that most people like to browse, they want to see what other people have done and are unwilling to ask themselves. Another study done by the Danish university "Syd Danske univeristet" indicated that if the students were forced to post an initial number of messages and responses to messages, the trend was that they were more willing to continue to contribute messages after the initial enforced period.

In a study carried out by Bluemink and Järvelä[60] they found that

> *"face-to-face encounters as a contextual support are essential for enabling rich interaction and fruitful collaboration to take place between the students and the teacher."*

Students also want instructors to correct their misconceptions and other student's wrong directions/answers, i.e. the instructor has to be involved in the community.

This then makes systems like the one described by Mayes in "Learning from watching others learn" [61], where dialogues between students and instructors were recorded and later made available to other students, both useful and interesting. The idea of getting some students to ask the questions from their perspective and then offering this to other students fits well with the above finding, that in some situations students prefer to learn vicariously.

In systems where students have overcome the barrier of posting comments and generally being involved in the discussions, the findings by Schellens and Valcke[62] confirm that students in discussion groups are very task oriented and that higher

proportions of advanced phases of knowledge construction are observed. They also found that the group size is important and discussions in smaller groups, less than 12 people, are the most effective and fruitful. This may change as people get more used to the format, but there is also the desire to have active learners, and there is a limit to how many active contributors one information channel may have at any time.

2.3.4 Is the work that goes into creating interactive learning material worth it?

The ease, with which some Web courseware tools today allow us to transfer our Word files and PowerPoint presentations onto the Web, encourages us to transfer material designed for one medium into another. A term used for such material is "shovelware". This shovelware will all be passive material with no interactivity for the students, this is a natural consequence because the source is non interactive. The importance of activating students is mentioned in various sections of this thesis.

The research done by Khalifa[63] attempts to discover if e-learning materials are more useful for students when they incorporate some interactivity. The experiment was carried out with two equal groups of students alternating between a "shovelware" setup (a PowerPoint presentation and a Word document), and an alternate setup of properly constructed interconnected documents. The findings in the study were clear:

> *"The Distributed Interactive Learning Web site was found to be superior to the Distributed Passive Learning Web site in terms of both the learning process and the learning outcome".* [63]

The results from the study showed that the extra work the educator puts into development of an interactive site actually pays off.

2.4 Structuring the learning material

There is a continuing goal to support each and every learner at an individual level. The desire to closely monitor and assist every learner as he or she moves through the learning process is not feasible from a resource perspective. The challenge that then arises is whether or not the use of computers could help achieve this aim. The goal of computer based learning should then be to make material[64]:

- *adaptive* to the individual,
- *generative* rather than pre-composed
- *scalable* to industrial production levels without proportional increases in cost

Learning objects can be and are used as a step in this direction, if they are coupled with an automatic system that can present different learning objects at different levels to different users in an automated fashion. Several EU funded research projects have been looking into this in the last few years, such as ARIADNE[65] KOD[66], 3DE[67]

2.4.1 Learning objects

Learning objects are units of material used in learning. Learning objects are small, relative to the size of an entire course, components that can be reused a number of times in different settings. Additionally, learning objects are generally understood to be digital entities deliverable over the Internet. Learning objects are usually made up of several different parts, mainly the learning material, but also descriptions of the content and other information.

There exist various definitions of learning objects. The final version of the IEEE-LTSC[13] standard adopted this very broad definition:

> *"Learning Object: For this standard, a learning object is defined as any entity, digital or non-digital, that may be used for learning, education, or training."*

The size and complexity of a learning object is up to the author, the thing to note however is that the smaller a learning object is the easier it is to reuse. Large objects tend to be locked into one context and can therefore only be used there. However learning objects needs to be self contained and not depend on other object. One sound principle when creating learning objects are to follow standard software engineering practices[68, 69], as suggested by Boyle[70].

The assembling of learning objects into bigger units is necessary in order to use learning objects in real educational settings. Assembling of learning objects was in the beginning presented according to a LEGO metaphor, in that it should be possible to combine learning objects in any way the users wanted. However, this metaphor does have its problems. It is clear that many, if not all, learning objects will demand that the student have some previous knowledge, and it is also clear to any who have been working in education that material for a course cannot be arbitrarily assembled into any order. Wiley[71] suggests another more appropriate metaphor, the atom, proposing that learning objects can be connected but only in certain patterns. Another proposal is that learning objects should have a "best before" date, as knowledge does get outdated and must be updated or at least reviewed at regular intervals.

2.4.2 Standards for Description of learning objects - Metadata

Metadata, literally "data about data," is descriptive information about a resource, in this case a learning object.

There are several standards available to describe Learning Objects. The major ones are: IMS Global Learning Consortium[14], IEEE-LOM[13], Dublin Core Metadata Initiative[72] and the most widely used The Sharable Content Object Reference Model (SCORM) [73]

SCORM specification was developed by the Advanced Distributed Learning project. SCORM is a standard for managing learning objects, and making them portable from one learning management system to another.

SCORM adopts elements from different e-learning standard groups such as the IMS, ARIADNE and IEEE-LTSC for different aspects like meta-data, content tracking and content sequencing, and integrate them with one another to form a more complete model.

A SCORM package, called a Sharable Content Object (SCO) contains:

- The learning objects specification,
- Content of the learning object.

The content is the digital media such as text, images, movie-clips, sound or any other form of computer data that can be delivered to a Web client. These are the smallest building blocks for content in SCORM and can be identified and reused through the

meta-data. SCOs are the smallest logical unit of instruction that can be delivered and tracked by a SCORM-compliant VLE. The mapping from learning objects to SCOs is implied in the SCORM standard.

2.4.3 The use of learning objects to facilitate personalised e-learning

The use of learning objects seems to be the focus of many people and projects.[74-76]. The basic principle is to use learning objects for the learning content and use the virtual learning environment for the delivery and importantly control of the delivery.

One such system is presented by Vanderpitte et al[76], in their system the Blackboard VLE is connected to an ARIADNE Knowledge Pool System. The system is implemented as a Blackboard building block and supplies the learner using the VLE with content from the Knowledge Pool System. The results published reports that automatic import all known information and even proposing highly probable values for other information was performed. Any trials with students were not reported.

2.5 Challenges in online courses

Completion rate of online courses for many institutions present a problem. The dropout rate in online courses tends to be higher than with traditional education. A study by Arbaugh[77] found that as learners become involved in more online courses, their perception of learning changes little but there is a significant change in their satisfaction with the online format of course delivery.

Research carried out by Levy[78] shows that the more experience learners have with the online format the less likely they are to drop out. There are possibly many reasons

for the dropout of less experienced online learners, but these two studies do indicate that if learners are encouraged to enlist on several online courses the dropout rate should decline.

Alternatively the simple reason may be that the less satisfied learners are less likely to enlist in a future online course, and thus a natural selection of learners more suited to the online format is achieved.

2.6 Virtual labs

Students must during their education acquire the ability to solve real world challenges similar to what they will encounter once they graduate. The best way to achieve this objective is to put them in a position in which they have to solve similar problems during their training. This is one of the objectives that educators pursue by including lab assignments or student projects. This fits well with the notion that learners have to perform some activity to learn, make the material their own and not being "fed" the material.

Lab assignments may have varying levels of difficulty. Easier assignments involve getting students to solve small problems according to an outline. However, an approach closer to real world practices involves setting up small projects described by specification documents. In this case, students should do these projects almost by themselves, as in the pure exploratory model of learning. The focus here is on a self-learning process by providing students with guidelines and providing feedback about their work, in a true constructivist tradition. They will be forced to apply different techniques acquired from several sources and can turn to instructors for help whenever they come up against a problem that stops them from progressing. [79, 80]

There is a lot of work going on in the field of remote labs around the world[79-90]. Most of the remote lab experiments that have been set up are in the engineering world. This is not really surprising considering that the engineering world is the subject area where the laboratory setup is the traditional form of learning. The engineering setups are generally the area where the possibility to set up simple experiments are the easiest.

Most of the existing remote labs are fairly simple and on the lines of:

- Set up a real experiment
- Include some parts of the experiment that can be changed via manual controls on a computer.
- Set up a camera to film the experiment.
- Send the images to a remote site
- Allow the people at the remote site to change the setting of the experiment in real time.

Setups like these are often easy to create, but they do however have several drawbacks. Being a physical system only one set of learners can utilize the system at any given time. Regulating the access to the system can also be a real challenge. The major advantages these systems have compared to simulations explained below are their inherent ability to produce accurate and appropriate results. There are plenty of examples of both complex and simple examples of remote lab systems,[81-85]

Other setups are based on either pure software simulation or simulation and cheap hardware connected to a PC (personal computer). The simulated setups are useful because they give access to a "real" instrument. Though the instrument is not physically there, it is either simulated by the PC, as with the Java based electronic instruments, or it is made by the help of a low cost box connected to the PC, as is the case with the virtual Oscilloscope. These simulated setups are a help where the students that does not have access to modern lab equipment. [86-90]

Setups like these are immensely helpful to give remote students a "feel" for the lab. Camera setups are easy to accomplish but do of course generate the problem with lab equipment and multiple access from many sites. These problems are not present in the simulated setups, but the problem with the simulated setups is the difficulty involved in setting up complex experiments and getting realistic simulation results.

2.7 Games based learning

There have been several studies performed showing the significance of using computer games in education. Henderson[1] published a study showing that playing a recreation video game provided beneficial informal educative experiences, even when used only over a short period of time. Secondly, the study provides support for the cognitive worth of playing games. It also contradicts the popular opinion by confirming that recreational video games are a significant cognitive artefact of youth culture, and lastly it showed the viability of stimulated recall as a methodological tool in game research.

One question in particular needs attention: "how does one design a constructivist-based learning system?" Such software is sometimes assumed to mean simply the use

of multimedia and/or hypertext. The simple use of multimedia elements or hypertext does not guide the developer into any specific form of pedagogical model. The controlled presentation and custom response built on top of these media are characteristic of basic instructivism. Research done by Becker[91] shows that even ordinary commercial computer games created without education in mind can be used in an educational setting and that they embody fundamental elements of educational theory.

Games based learning is slowly gaining a foothold in traditional education systems, and many of games are where learning mechanisms are layered on top of the educational content. There has been an overt shift to constructivism in education in recent years, but as Herrington and Standen[92] observe the influence of behaviourism and drill-and-practice is still apparent in most games that are developed for education as well as in other software for education. Many learning games offer only traditional didactic methods in disguise, in these cases, the content and teaching method are entirely unchanged from their non-game origins. Usually the content is basic linear material pushed into a game context. This is similar to the production of shovelware, Khalifa[63] shows the dangers of such an approach. Hangman is a game in this category, such games are often based on the principle of avoiding mistakes, and can be applied to a variety of learning goals. The effectiveness of this type of game tends to decline as the student/player's experience and sophistication increases.

This is not to say that these sorts of learning games have no place. They can often provide the motivation to learn in cases where the students have no other motivation to engage with the materials. Wrapping "boring" content in a trivia or "shoot them

up" game format might make material that just needs to memorized a bit easier to "swallow". Likewise, repeated engagement with interactive drill-and-practice environments provides the repetition that may be needed for students to memorize and retain certain types of content. Galarneau [93] describes

> *"the first step towards constructing one's knowledge is being open to the experience of learning. An unmotivated student is simply incapable of taking enough interest in something to engage in the process of construction".*

It can be argued that technology can be used to support constructivism, but technology as such is neither inherently constructivist nor necessary to support it. A number of educational institutions develop web-based course material that includes interactive quizzes, animation or video extracts, and hyperlinked concepts intended to engage the student in ways superior to earlier technologies (not much video and animations as the effort involved in developing these is large). Other types of games involve the content being woven into the game. Currently many of this type of game use simulation, and the educational potential of simulation depends on what one wishes to teach. Many of these claim to be guided by a constructivist viewpoint in their design. Yet when examples of the courseware are demonstrated it becomes clear that constructivist principles are little in evidence. Most interactive quizzes used behaviourist principles of drill and practice. The video-based material was presented as a traditional lecture in much the same way as early instructional television. Lastly the hyperlinked concepts were organized as is customary in traditional instructional design, a reasonable and effective strategy, but not constructivist in nature. Such

examples reinforce the view that the use of the technology itself neither imposes nor enforces constructivist development.

2.7.1 Storytelling in learning

Adventure and role-playing games uses the concept of stories to give the player a feel for the environment and to drive the game forward. The use of storytelling in education provides us with a mechanism to establish a relationship between games and virtual learning environments. Storytelling is by many referred to as "the original form of teaching". Storytelling is one of the most effective techniques for conveying information in a compelling and memorable way. Many cultures have long traditions for telling stories to ensure people remembered a message. The trick is to provide just the right amount of suspense and excitement in the story to motivate the audience to keep listening. Bielenberg [94] describes an experiment where students learned with stories and clearly remembered the facts better.

Stories can help provide a structure for the information and can communicate information at several levels at the same time.

> *"A story can simultaneously provide a context for the learning task, teach deeper cultural messages, give an emotional impression and ultimately help tie learning to personal experience."[94]*

A story can also be a powerful motivation to keep going, and find out what happens next, thereby helping the students to complete a course, in the same way stories are used by the entertainment industry to make us watch next episode, next movie or log on to a computer game and continue gaming.

From early times the storytellers in the oral traditions used memory aids to recall long and complex stories. The memory strategies they used followed an ancient technique first described by Simonides of Ceos (Greek poet 556 BC – 469BC) as building memory places. The storyteller would travel through these memory places in his mind, thereby remembering the elements in the right order. Other examples include the native peoples in North America's Northwest Territory have passed down detailed methods for hunting and storing of reindeer and whale that include geographic information that still holds relevance today

The need for an oral tradition as a means of recording history and facts has diminished in practical value with the advent of the written text and the rapid growth of computers as a means of disseminating information, it does however still have its value in the process of learning.

2.7.2 Online games

Online games have been around for a long time, at least from the early seventies. Most of the games during this time have been of the text variety, these games fall into a category referred to as MUD (Multiple User Dungeon & Dragons). A MUD is a computer-program which users can log into and explore. Each user takes control of a computerized persona/avatar/incarnation/character. You can walk around, chat and interact with other characters, explore and solve puzzles. In some versions of MUD you are also allowed to create and expand the games environment.

During the last decade we have seen the formation of new types of online games referred to MMORPG (Massive Multi-user Online Role Playing Games). These are

graphics rich environments with literally thousands of people interacting in real time. Examples of games like this include Halo2[95] and World of Warcraft[96].

2.8 Benefit of a games based VLE

Online games setups can be used as a basis for a learning environment. There have been numerous trials of this in the form of simulations, MUDs and adventure games[97, 98]. During the last few years multiple virtual worlds have been developed for general communication between users from different parts of the world. Some of these are environments where people can meet and chat, while other environments give the users the possibility to contribute and create worlds and virtual objects by themselves. Major environments in this area are e.g. Active Worlds[99] and Second life[100]. Addition has been made to both these by universities to try to utilise them as virtual universities.

The increased availability of high bandwidth connections to support multi-user, graphics-rich environments such as gaming environments supports the use of these gaming technologies for virtual learning environments.

2.8.1 The engaging nature of games

The concept of flow was introduced in 1975, through a study of people involved in activities such as rock climbing, chess and dance[101]. They describe flow as a state of complete absorption or engagement in an activity and refer to the optimal experience. During optimal experience, a person is in a psychological state where he or she is so involved with the goal driven activity that nothing else seems to matter. According to flow theory, flow can occur when an activity challenges an individual enough to encourage playful, exploratory behaviours, without the activity being

beyond the individual's reach. For example, if the activity is to demanding it may produce anxiety rather than flow. Or, if it is not challenging enough, boredom, not flow, may be the result

Past research[102] has shown that the flow state has positive impact on learning. A more thorough explanation in connection with computer games for learning has been produced by Kiili[103].

2.8.2 Natural interest from the younger generation

There are lots of people that are already familiar with the gaming format, which means that there is no requirement for them to learn this as a new environment for learning.

The benefit of storytelling in educational games is that it gives us, as creators of educational material, access to all the same emotional factors enjoyed by ordinary game creators, such as emotional attachment. Once you've hooked the audience emotionally, if you know how to manipulate them in the right way, you can keep and grow that audience for a long time, getting the students to spend more time and work harder at the learning material which should result in improved learning and retention.

2.8.3 Learning by doing

Offering the students the opportunity to explore a new environment is giving them the potential to use one of the most potent inbuilt feelings in humans, curiosity. With the power of hindsight most people will say that making mistakes is what they learned the most from. A popular phrase being:" People should be allowed to make their own

mistakes". One challenge for us as educators is allowing our students to make these mistakes in a safe environment.

Students in a simulation or any active environment are also actively encouraged to be creative. The simulations must give the students enough freedom to allow them to explore and make mistakes, as mentioned above. Giving the students the option to explore their environment does give its own challenges, the simulation itself is more complex to create, and requiring more effort in addition the students can get lost and frustrated. Techniques to help guide and direct the students in the simulation or virtual environment are discussed later under the headings of scaffolding and getting help.

In games players make things happen, they do not just sit back and let impressions and events wash over them. Video games are by definition interactive and will force the players to participate in activities not just be a passive spectator.

2.8.4 Hard fun

"Hard fun" is something that happens when people are involved in something that is both meaningful and satisfying to them. "Hard fun" is the "flow" that occurs when time flies because you are stimulated and engaged, without all the resources you need and dealing with a challenging problem. "Hard Fun" is hard but it is fun because you are able to perform a difficult task. The important part here is: difficult/hard and able to perform. Some are advocating taking the hard work and discipline out of learning. What we should be doing is finding tasks that will harness the passion of the student to do the hard work needed to master difficult material.

There are numerous examples of industry projects, that start out as unsupported underground projects, that later becomes major official projects. Workers will sneak into labs and continue to work on projects after hours, without any other reward than the reward of making something work.

There are also many educators that argue for the role of frustration in the learning experience, or more precisely the resolution of the frustration. We as educators must be careful with the use of or inflicting frustration on students during the learning process. The final resolution of the frustration is a powerful stimulator and source of great joy, the major problem with this approach is frustration can and will turn many students off. There will often be some frustration when moving into a new area of learning, the use of scaffolding and increased help to struggling students as described in the design for our system is targeted at reducing the frustration and ensure that the students are not turned off the whole experience. On the other hand the system must not make the challenges too easy and turning the students off in that way. This topic is covered previously under the heading the engaging nature of games, flow and by Csikszentmihalyi[104].

An interesting note on the self reward of learning is reported by Gee [105]:

> *"Harlow wondered what the monkeys would do if they were confronted with the puzzles, but given no food rewards. He predicted they would stop at the first step if they received no rewards. But the monkeys did no such thing. They worked on the problems, and solved them, just as eagerly and readily as when they had received food rewards. For the monkeys, learning was a reward in and of itself, a reward*

powerful enough to keep them happily going at problem solving for long stretches of time."

It is a well known fact that, (young) people are not always eager to do difficult things. When educators are faced with the challenge of getting students to do so, two choices are often available. The first solution is to force them or, an alternative temptation when profit is at stake, which is increasingly the case in the education system, we can lower the requirements for a pass mark. For the gaming industry neither are an option, the industry can't force people to play their games, and games do not want short and easy options. For people interested in education, this raises an interesting question: "How do game designers manage to get new players to learn their games which are often long, complex and difficult, and even pay for the privilege?" Gee[105] answer to the above question is: "The answer, I believe, is this: the designers of many good games have hit on profoundly good methods of getting people to learn and to enjoy learning." He goes on to claim that "Under the right conditions, learning, like sex, is biologically motivating and pleasurable for humans". This is possibly pushing it a bit too far, but there is an observable fact that at times this is true, learning is a pleasurable experience.

The idea that we get the student hooked on learning as a pleasurable experience and not something they have to force themselves through must be every educator's dream, and should get the reaction:" We have to learn how to do this."

Computer games are engaging as argued earlier. Aldrich[106] have also shown that students involved in a simulation with some game elements will spend around 50% longer learning, than in a similar environment without the game element.

Computer game designers are working very hard to make people finish a game they have started on, and preferably buy the sequel or next game in the series. One "trick" game developers use to get a player to stay with the game or, when they have to leave, make them have the urge to return and continue, is by establishing emotional connections with the on screen characters. The emotional connection can be with both the avatar used by the player and/or in game characters and non players characters (NPC). The emotional attachment between players is discussed in the section on socialisation in a game environment. Freeman[107] presents this topic in his book on how to create emotion in video games.

2.8.5 Keeping learners active

Students learn more, and enjoy themselves more when they are actively involved, rather than just passive listeners once they get out of the passive state that is the unfortunate state of some education systems. Passive mode learning is the easy option for the students in the short run. Given the choice, many students will first elect to go for the MTV (Music Television) option when it comes to education, everything is prepared and you just sit back and let it wash over you. Students who are not brought out of this passive state will usually learn little of the material thus presented. Lecturers/Tutors and students will tend to blame each others for the poor results in the assessment. One of the points made in constructivism is to get the students involved in the process, and give the tutor the role of facilitating and supporting learning. Most

students will, after some initial misgivings, elect to follow the active learning route and get involved in the learning process. The rationale for this is that it is simply more enjoyable. Many people are advocating taking the hard work and discipline out of learning. However, others argue that this is not the answer. Rather, what should be done is finding tasks that will harness the passion of the student to the hard work needed to master difficult material, like previously described under "Hard fun"

Therefore, one main aim for us as designers of learning material is to design content in such a way as to allow different students to obtain the state of flow, irrespective of their different knowledge and abilities.

2.8.6 Exploration

Exploration and the freedom to direct one's own learning is fundamental to constructivist methods. MMORPG are inherently games that allow just such exploration and freedom. A MMORPG typically offers the player a number of options like available paths and environments to explore and different quests to attempt. One of the challenges for a game designer is to help new players avoid getting lost and overwhelmed by the number of options available. All educators agree that showing students the entrance to the library and then letting them get on with their learning is not an efficient or even sensible strategy for education. New students in the system will need to be guided and led, while maintaining enough freedom to allow them to explore and direct their own learning. This guidance is what previously is referred to as scaffolding.

2.8.7 Games based personalisation

There is a continuing goal to support each and every learner at an individual level. The desire to closely monitor and assist every learner as he or she moves through a traditional learning process is not feasible from a resource perspective, our solution is to utilise games based computer systems.

The practical solution to personalisation can be done on multiple levels. The basic level is to adapt the starting point and available tools for the students, games like Civilization utilise such an asymmetrical structure, much as an education game can do. The different players does not start with the same assets, in a regular game this is used to enhance the drama and make the game more exciting, in an educational game this could be used to represent different starting points based on the individuals background.

Personalisation at a more advanced level can be performed by tracking student's progress and adapting the material presented as the system gains more information about the student.

2.8.8 Reassessment and games

The problems surrounding how to deal with students that fail the assessment are built into games from the very start. When faced with a new game nobody is expected to be able to play through on the first try, if somebody would be able to complete the game first time, the game would not be any success as it would be deemed too easy and players would quickly get bored.

The usual procedure for approaching any dangerous places in a game is to save the game status and then if you die restore and retry. This procedure can be repeated as many times as are necessary to complete the task at hand. Any educational system based on a game concept can use a similar method, with some small alterations. In an educational system there would be no need for the student to save the game state before entering into a quest or any other are in the system, the quests would generally be non violent in nature and the scenario where the player are dying would not exists. Even if the specifics of die and retry scenario cannot be used the general idea would be applicable.

The system must track all students' progress through any learning scenario and store information on number of attempts and general progress or lack thereof. In a regular game the quest would not become harder or easier in the game model, but the player would acquire knowledge of where the villains and problems are and act accordingly. In an educational system where the aim is learning, the system has the added option of making more help available, this can be done in the form of hints, non players characters (NPC) that are helpful, other players (lecturers/teaching assistants) that are alerted by the game that somebody is struggling or any other way the creator of the learning material deems useful. The sole focus in this part is on learning not assessment. Assessing the students learning comes later.

2.8.9 Social aspects of learning

Constructivism promotes social and communication skills by creating a learning environment that emphasizes collaboration and exchange of ideas. The challenge of doing this in an e-learning setting is greater than a face to face setting, which is why

the group quests and other socialisation activities in the designed learning environment must be included.

Most people benefit from a social community setting when they are involved in learning activities. Having others to discuss their experiences and difficulties with or to try out ideas is helpful. This social community is present in lectures and tutorials. It is not our view that learning can only occur face to face, but rather that social activities are an important and significant part of the process. As Mayes[19] puts it: "Lectures are occasions where the individual is confirmed as a member of a learning community." One of the challenges in online learning is to create this feeling of belonging to a community. A study has shown that online graduate students can feel connected to their virtual classroom community and students with stronger sense of community tend to possess greater perceived levels of cognitive learning. This may be taken as an indication that it is possible to accomplish the all important social interaction and sense of belonging in an online format. [20]

2.8.10 Social Relations in the Virtual World

In order to play the proposed game, only a minimum level of social interaction is necessary. It is expected based on findings from MMORPG that most players seek more. Studies by Kolo and Baur[108] have shown that many players not only connect to a online game in order to play but also to stay in contact with the fellow players, many players also connect to fellow players via messaging systems that exists outside the games environment during game-play. They engage via their characters in various social interactions from trading or fighting to entertaining other characters. Additionally most players are members of several social units like guilds inside an online game.

2.8.11 Communications in online games

Many players regularly meet the same characters online and interact in a fairly fixed group of co players. Kolo and Baur[108] have also shown that in particular, "there is a significant correlation (at the one percent level) between the number of sessions and the persistence of interaction partners." This shows that knowing and meeting people in an online environment or game triggers frequent playing and not the other way round. Manninen[109] has shown that the communication between players can be enabled by a relatively limited form of communication.

Manninen[109] has shown that the communicative aspect of current multiplayer games is enabled by a relatively limited set of interaction forms. Still, the available features of the games that contain a limited amount of language-based communication would seem to be enough to enable a certain level of communicative action. This level, however, is usually achieved by overcoming the restrictions and limitations of the system.

Although contemporary multiplayer games would seem to have an adequate level of communication support and engaging representational features to enhance the computer-mediated interaction, there are still huge gaps to be bridged. The interaction form model described by Manninen[109] can be significant for game designers, as it illustrates a possible representation of, for example, non-verbal communication in networked settings. As a result, it is possible to reduce the limitations and restrictions of computer mediation by enabling more flexible and natural interaction.

2.8.12 Communication outside the game, both electronic and person to person

Players that have communicated a fair amount inside a game tend to expand their communication to also include communication channels outside the game. Game players are regularly meeting up both to play together as shown by Kolo and Baur[108], but also meeting by other means, not only via internet relay chat (IRC) or other electronic communication, but also face to face.

Students meeting face to face after a game session will continue to discuss the stories that have unfolded in the game environment, and they will naturally continue to discuss other topics that were discussed during game-play.

2.9 Conclusions

The conclusion that can be drawn from the literature review indicates that the creation of a new or the enhancement of an existing virtual learning environment (VLE) with special features seems to be desired. Among the features such a VLE must have is inbuilt support for constructivist pedagogy and computer games elements to create engagement and motivate the students. A VLE integrated with computer games will probably also help increase the completion rate of online courses.

The reasons for this choice of a game based VLE are several:

- Generally computer games require players to take an active role in the activities performed;

- Computer games metaphors and underpinning models are inherently constructivist in addition the gaming format is also known for its ability to engage
- Games are built to offer a freedom for the player to explore the environment and material;
- The gaming format also lends itself to support the known advantages of narrative from oral traditions; and the model fits with a younger age demographic, and their interest in current trends in the entertainment industry.

Accepting that a game based VLE are needed the task will be to create a conceptual design for such a games based learning environment. The second task will be to indentify a suitable development platform as a basis for the third task that will be to create prototype implementations to test whether such a games-based environment is a viable way to present learning material for higher education.

The set of requirements for a games based learning environment will include the usual requirements for a VLE:

- Presentation on learning material
- Track students
- Support communication

In addition the following "new" requirements:

- Multimodality
- Inbuilt support for constructivist pedagogic models.

- The design must ensure that the environment is used and reused by the participants. This is accomplished by relying on games based metaphors and models.

The reasoning behind the requirement for supporting games based metaphors and underpinning models are their ability to engage, reinforce, and because they are inherently constructivist.

In addition to the "new" requirement of reuse and games metaphors and models, there are a need for good support, better that is available in the traditional VLEs, for multimodality and socialisation. The argument is that the social interaction of a community is important, if not vital, in supporting and contextualizing learning.

The requirement that the design of a games based learning environment must ensure that the environment is used and reused by the participants is the same as the commercial game producers try to achieve, though for different reasons. In a learning context the benefits of revisiting, reinforcements, drill and practice is well known. The effect of repeated exposure to the same information again and again ensures that the information is retained and it aids in understanding and learning. Deep learning requires the commitment of time and effort. The gaming industry have invested heavily into getting players to commit the necessary time and effort to master their games, the challenge for educationalists is to tap into the same feelings, getting students to devote the same time and energy into learning as they do to playing games in the evenings. The result of this work is that games are motivating and engaging, especially MMORPG which has the added feature of socialisation. Therefore the

students has this absolute context of the idea that they will keep on trying until they succeed, they will keep on revisiting the same context again and again to get to the point where they are able to progress. This is unlike the situation in learning where the students tend to shy away from areas where they have encountered failure and or problems. In the game a failure is seen as a challenge and they will keep going because eventually they will be successful. Even after succeeding they may go back and redo to gain greater skill in the problem areas. This is one of the reasons for integrating learning content into a game context.

There is no desire to replace all learning models with games based learning. The aim is to offer one more method to complement the existing models. Computer games can offer multiple representations of the learning material for reinforcement but the reinforcement of other, possible more traditional forms of learning are also effective in supporting the learners.

It is an observable fact that at times learning can be a pleasurable experience, and the main aim will be to create a design for a learning environment that aids the students by motivating and engaging them in learning activities. The notion of getting students hooked on learning, rather than seeing it as something they have to force themselves through, is every educator's dream.

3 Design of a game based virtual learning environment

The topic of this chapter is a conceptual design for the future use of computer games technologies and games based narrative to support e-learning and as a tool for lifelong learning. The conceptual design show the outline design for a system that utilises games based technology to support virtual learning environments that are constructivist in nature and utilise narrative for the learning process and student created narrative for the assessment process.

After the conceptual design that is presented follows a section describing the process of identifying a suitable development platform for the development of prototypes based on the conceptual design. The last section in the chapter describes the development process that led to the prototypes.

The conceptual design presented in this chapter has been previously published as[4] "Exploitation of games and virtual environments for e-learning" at ITHET 2006 in Sydney, Australia.

3.1 Learning and assessment in a Games based learning environment

The aim is for the student coming through the game to gain concepts and understanding in a constructivist and exploratory model, which is arguable, inherent in MMORPG games, in that they allow just such exploration and freedom. A MMORPG typically offers the player a number of options such as available paths and

environments to explore, and different quests to attempt. The premise for the learning is that the students in the game are faced with the task of constructing a narrative in a constructivist fashion, with scaffolding that gradually fades as they progress up the levels and narratives that are adapted to the concepts that are being assessed. Showing students only how to get in to a learning environment and then expecting them get on with their learning unaided is not an efficient or even sensible strategy for education, so new students in the system will need to be guided and led, while maintaining enough freedom to allow them to explore and direct their own learning.

The student will when going through the game collect a number of items or concepts during the learning phase. When they have collected the required or desired number of elements/concepts, and have acquired an understanding of the context of these elements and how they fit together, they will progress and attempt to complete the assessment. The students are free to explore their environment, and the elements/concepts that they are required to collect and understand need not be collected in any specific order. The context of where and how the collected items and concepts are found provides the basis for how these are to be understood, and can later be used to demonstrate this understanding in the constructed narrative.

At the point where the student has completed a predetermined number of quests they will be allowed to progress to assessment, this requirement is up to the designer of the learning material. The reason why the student may be required to perform a certain number of quests is to ensure that they have completed some activity within the environment, and is familiar enough with working inside the environment to be able to complete the assessment. At the point that the student is allowed through to the

assessment, it is known from the requirements that the students has completed some quests requiring them to undertake some work on the material and familiarise themselves with the environment. Since the system can track them it is also known which quests they have attempted and how they performed, this information can be utilised in later feedback, as recommendations following completed assessment attempts. Spending some time working with the learning material will also give the student a clear understanding of what is expected of them and an opportunity to get involved in the social dimension of learning and possibly help others.

3.2 Features the environment must support

Based on background survey[2] and general information about learning, there are a few features that are paramount that a learning environment supports.

3.2.1 Exploration

Exploration and the freedom to direct one's own learning is fundamental to constructivist methods. MMORPG are inherently games that allow just such exploration and freedom. A MMORPG typically offers the player a number of options like available paths and environments to explore and different quests to attempt. One of the challenges for a game designer is to help new players avoid getting lost and overwhelmed by the number of options available. All educators agree that showing students the entrance to the library and then letting them get on with their learning is not an efficient or even sensible strategy for education. New students in the system will need to be guided and led, while maintaining enough freedom to allow them to explore and direct their own learning.

As an aid for the students in the explorations of learning material the use of scaffolding to guide and direct students is one way to strike a balance between control and freedom. This scaffolding coupled with a clear and understandable goal for students helps to keep students focused and motivated with a sense of accomplishment when goals are reached. The understanding of setting and communicating these clear goals to the students are something the content developers/educators must keep a focus on.

3.2.2 Personalisation

There is a continuing goal to support each and every learner at an individual level. The desire to closely monitor and assist every learner as he or she moves through a traditional learning process is not feasible from a resource perspective. The challenge of offering personally tailored learning material to every student can only be solved by using computers. The general goals of computer based learning are that material should be:

- adaptive to the individual,
- generative rather than pre-composed,
- scalable to industrial production levels without proportional increases in cost

The suggested way of solving the personalisation of learning material is to utilise learning objects. As noted in [2] *"Learning objects can be used as a step in this direction, if they are coupled with an automatic system that can present different learning objects at different levels to different users in an automated fashion."* One of the ways to accomplish this would be to base the automatic delivery system on computer games.

The practical solution to personalisation can be done on multiple levels. The basic level is to adapt the starting point and available tools for the students, games like Civilization utilise such an asymmetrical structure, much as an education game can do. All players do not start with the same assets, in a regular game this is used to enhance the drama and make the game more exciting in an educational game this could be used to represent different starting points, or to force different players to cooperate in the game.

Personalisation at a more advanced level can be performed by tracking students' progress and adapting the material presented as the system gains more information about the student. This method is described in section 3.2.4, reassessment.

3.2.3 Narrative based assessment

The use of narrative assessment is a good way of demonstrating understanding. The desire is for a method for assessment based on a student demonstrating their understanding of a topic by creating this narrative. The main challenge with such a narrative based assessment is to mark and generate feedback quickly. So to maintain flow and support the games model there is a need to automatically assess this narrative.

3.2.4 Reassessment

The problems surrounding how to deal with students that fail the assessment are built into games from the very start. When faced with a new game nobody is expected to be able to play through on the first try, if somebody would be able to complete the game first time, the game would not be any success as it would be deemed too easy and players would quickly get bored.

The system must track all students' progress through any learning scenario and store information on number of attempts and general progress or lack thereof. In a regular game the quest would not become harder or easier in the game model, but the player would acquire knowledge of where the villains and problems are and act accordingly. In an educational system where the aim is learning, the system has the added option of making more help available, this can be done in the form of hints, non players characters (NOC) that are helpful, other players (lecturers/teaching assistants) that are alerted by the game that somebody is struggling or any other way the creator of the learning material deems useful.

3.3 The design for the games based model

In the design for the game based learning environment the subject area is divided in topics and subtopics, which are then modelled as levels within the game. The different levels will contain multiple quests each representing some areas of material that the student should learn. These quests will model the learning material. The quest form is borrowed from existing computer games formats. See[110-112]. The quest format is built on the simple principle of setting some task for the player and then rewarding them on the successful completion of that task. If the player does not succeed the option is to go back and try again. Successful completion of each of these quests will provide the students with conceptual information related to the topic of study. The aim of the game is to complete all the levels. The progression in the game is controlled via the assessment part of the system.

During a quest the player can be given any amount of help, the aim of the game is to learn, not to determine if the students are capable of learning on their own. The

outcome of quests does not influence the judgement of the outcome of the assessment process, but it may be used as a means to control access to the assessment. This separation of assessment and quests, and the summative and formative assessment, is in order to allow the student to receive any help necessary from the game-environment, fellow students or instructors during game-play.

The game based format is inherently constructivist and does offer a way to get multiple attempts at solving one task and can be constructed in such a way as to offer an increasing amount of help on each rerun. The student is offered the opportunity to retry the same tasks multiple times. Different students will therefore be offered different support during the learning phase, dependent on the student's actual needs. When the student arrives at the assessment phase of the learning period all scaffolding and support will be removed so that the student can demonstrate their understanding of the topic area.

3.3.1 Interface

3d graphical virtual environment, support for both graphics and the networking are built into the chosen games engine. The support for audio and possibly video group communication in real-time are other features that must be supported in a completed system, these features can be also be supported by an external system to the game itself. The argument can be made for both solutions, both internal and external. An internal solution is easier to set up and maintain. Whereas an external solution will be more flexible and is the preferred solution in online action games of today, mostly due to the impact it may have on response time for the network packages updating players on the ongoing action in the game.

3.3.2 Navigation

Navigating in a large 3D world inside a MMORPG game is often a bit tricky. In regular computer games navigation a route back to earlier places in the game is often used to add to the challenge of playing. In regular games exploring and finding hidden secrets are part of the game-play, in an educational game one would generally not try to make learning material difficult to find or relocate for the students. It may be desirable to hide some small surprises and entertaining features but the general bulk of the material should be easily locatable. The aim is to make the content easily findable and relocatable for the students, but the design of the navigation system must not remove the exploration factor.

The proposed design solution for this is an auto generated 2D clickable map. This map will mark all places that the student has visited and can be used for auto move. The auto move feature is added to save the player from moving through long stretches of game environment just to get to an area of learning material that is wanted. The auto move feature will remove the hassle of navigating known areas, but keep the need to explore new areas.

3.3.3 Gaming concepts

3.3.3.1 Items

The student will be presented with items when they complete tasks. Items will typically be similar to real world objects. Items can be: SMS (Short Message Service) tool, Mobile phone, Laptop, keys, cables, wireless access card and other upgrades for the laptop, radio link (multiple and unlimited mobile phone), video phone and video link(multiple and unlimited video phone). The limits will only be set by the

imagination. Some of the items will be required to perform some quest, most will only be for show and items for showing off to other players.

The useful items will typically be given in a number of quests. Most of them will be given during the first few "learning the system" quests. These "learning the system" quests are the first few quests set for the user to familiarise themselves with the system. This is a much used method in MMORPG's to teach new players about the system and controls.

3.3.3.2 Quests

From Wikipedia: "A quest is a journey towards a goal with great meaning and is used in mythology and literature as a plot device. In literature, the objects of quests are often a lengthy distance from the hero's starting position. This requires much travel and allows the author to showcase the exotic locations and cultures of their fantasy world."

A typical quest will start with the heroes having to assemble some artefacts, which unfortunately for them have been stolen/hidden and/or broken into several pieces, each of which is guarded by terrible threats which the heroes must overcome.

A quest in a gaming context, especially in MMORPG, is generally a task or series of tasks, which a player or group of players may complete in order to gain a reward. Rewards may include experience points, loot, spells, in-game currency, faction hits, or any combination of the above. In a traditional computer game setting the game-play is performing the quest and the reward is the aim and whole reason for completing the quest. For the quests in the education game proposed in this paper, the aim is to learn

during the quest, the reward is only a small token to mark the completion of a quest. The result of this is that the focus is actually shifted from completing the quest to learning during the quest.

The main benefit for the player in the long run is the learning that takes place as the quests are worked through. In addition to learning, the student will be given some item inside the virtual world at the completion of the quest.

The quests will initially typically be "learning the system" quests. These quest will teach the student about the system and the items given will be useful in the virtual world. These quests will also give the student the most basic items required to perform some of the quests in the system. (Communication-tool, laptop and so on) The advantages of this approach are that the students are trained on the system that they will later use.

Group quests will require the students to cooperate to solve the task at hand. One simple way to ensure that there are multiple students in a group can be that when they embark on the quest they will have to create a private network with their laptops, each student only being able to carry one laptop at any given time. This will also require the students to set up communication and other collaboration tools they need during the group quest, before they start.

The completion of quests will not influence the progression of an individual student, but results are recorded. The Quests can be a simple completed/not completed type or graded. Upon the completion of any quest the player completing the quest must have

an opportunity to indicate if anybody helped him during the quest, or attempted to mislead him. The players may be awarded for helping others this, being in the form of money in the game.

The outcomes of quests are:

- Learning takes place
- Feedback on personal progress
- Collaborative learning - The opportunity to guide other through quests -> result in money

The quests do not influence the assessment outcome. The assessment does not use any of the results or number of attempts on quests as input, but it can recommend that the student revisits or attempt some quests as an outcome.

3.3.4 Levels

The virtual world will consist of multiple levels. Most levels will have an access limitation and only be accessible to students with a high enough status, in other words they have to progress far enough in the material, and prove they have learned the material through assessment, to be allowed access to more material.

The designers of the learning material will be free to control access to levels and can make levels free access or dependent on the completion of certain tasks, score in assessment or any other information that is logged by the system. The envisaged design for the system is based on a central access control area that allows the standard access to all levels, most will be blocked off initially but opened as the student passes assessments. In addition to this central access, designers of the learning material may offer access to levels or parts of levels that are not accessible for the student.

Using a building as a model, the main lobby with elevators will offer the general main access point. Elevator buttons will become available as the student passes assessments. The designer of different levels may offer additional means of travel between levels this can be via backstairs or small local elevators. Access to these stairs and local elevators are up to the designers of the different levels to control.

When designers of learning material offer access to new levels for students they must also allow the students to later return to complete unfinished levels. This can be via the same local transport or via the main elevators.

3.3.4.1 Money

The concept of money in the game can be an interesting one. It is desirable that students helping other students will be given a salary or other advantage, given by the system. After one particular student has finished a quest he can give credit to other students for helping him. This credit can only be given to students that have previously completed the same quest. The salary given to the helper will be determined by two factors, the amount of help given (rated by the student that was helped) and the result this student achieved on the quest. This will be useful where the outcome of the quest is graded and not simply pass/fail.

The earned money can later be spent in the social areas of the game. The money will not help in completing quests or in assessment. The credibility of the whole learning environment could be ruined if money is used in the assessment process.

The main reason to introduce money is to give an extra incentive for students to help each other.

3.3.4.2 Experience point –progression in the game

The student will acquire status/experience points in the game by completing assessments, experience points are what controls student access to new levels and areas of the game. The only way to gain these points is to complete assessments, no amount of completed quests, items or money will give higher access to new levels. The assessment procedure itself and the work on assessment are described later in this paper.

3.3.4.3 Social areas

The game will have areas that are designed to be purely for social interaction and recreation. The social areas in the game are envisaged to have at least three functions:

1. Meeting place and interaction opportunities for non learning material. The social areas will be areas of the game environment where the players will not be supervised or closely monitored. The areas will offer an opportunity for players to run away to or communicate about topics outside the learning situation. This communication is handled in a traditional learning environment by taking a break, going outside for a coffee or smoke, chatting about last night's movie or if the students should meet up later. This communication option is not a necessity for the gaming environment but should be fairly easy to implement and will offer something extra for the students.

2. Creative outlet for players. Inside special areas of the gaming environment players can be allowed to create their own items, elements or even areas. The creative spirit of game players/students is enormous. Most of the large commercial virtual worlds that people can log into offer the opportunity to create your own virtual living space. Inside these commercial virtual world people have been known to spend months and months creating unique areas inside the virtual world, it is a shame to waste this creative spirit and not utilise it to create a more interesting virtual learning environment.

3. The final social area is places to spend the virtual money students acquire helping others during the quests. The money spending areas can be places like shops, where players are allowed to customise their avatar, 100 Virtual coins for a green jacket, or 500 for a bright red one. Anyone seeing your avatar after the purchase of the red jacket will know that you are a player who has lots of money and are a great help on the quests, getting the player with the red jacket even more money by attracting attention from people needing help.

3.3.4.4 Getting help (Student-instructor, Student - Student)

Most people benefit from a social community setting when they are involved in learning activities. Having others to discuss their experiences and difficulties with or to try out ideas is helpful. One of the aims of the designed learning environment is that in all the learning and social areas students should be able to communicate with all other students and staff that are present in the game. Some communication will be limited to face to face, avatar style, you are only able to communicate with the other avatars that you presently see. Distance communication will be possible via items acquired, such as mobile phone, sms tool and video conferencing equipment.

3.3.5 Multilevel

The subject area is divided in topics and subtopics, which are then modelled as levels in the game. The different levels will contain multiple quests each representing some areas of material that the student should learn. The aim of the game is to complete the levels. This is done via the assessment part of the system. The quests are only there to aid in the process of learning, the only way to progress is to demonstrate knowledge by passing assessments. There is also a possibility to model in ways to gain access to higher levels in the game without necessarily completing the current levels. The decision on what levels should be accessible at any one time is left up to the designers of the levels

3.3.6 More traditional modelling of learning material

3.3.6.1 Lecture theatres

These can be recorded or even live lecturers given by members of staff. These rooms/areas can be modelled as traditional lecture theatres, meeting rooms or any other layout the designer of the level feels are appropriate to offer.
The other form of lecture can be the pre-recorded one. These lectures can naturally be individually controlled by the students and be started, stopped and jumped in at will.

LIVE: The virtual environment may contain areas where live lectures are given. If there is a live lecture the students will have to behave in much the same way they do in real live lectures, avatars of all students present will be visible for the person giving the lecture, and the audience will be able to see and listen to the avatar giving the lecture. Students can ask questions and interact with the lecturer, but their action will

be viewed by all other people present at the lecture and disruptive behaviour or "noise" might be a problem.

Compared to one-on-one guidance there is several clear advantages: Live lectures will give an added feeling of belonging in a community in the same way a traditional lecture does. The lecturer is able to give multiple users that are currently logged into the system at that time the benefit of what is happening, but as with traditional lectures the students will be treated as a group and not receive individual attention.

RECORDED: The other lecture format can be pre-recorded lectures made available to students. These can be in the form of a recorded lecture in the virtual world (A bot/robot avatar copies the previous live lecture), or just a video that is running. The advantages here is that the students are able to control the pace (start, pause, fast forward, rewind) but are not able to ask questions and get an immediate response.

3.3.6.2 Laboratories

Labs will be areas where people can meet up and do experiments and prepare for quests. The material in the lab may be similar to quests and but it may also contain some half solutions readymade with easy to understand descriptions. There may also be a way to allow bigger freedom in what to do than are allowed in the quests, the action in the lab does not have to be evaluated, and the students can be free to experiment. During a quest action has to be evaluated to provide a feedback at the end, even though quests are not assessed for marks, the monitoring and assessment that takes place may be a factor for some students.

The ability to train and perform experiments and give the chance to train for quests and assessment is an important part of the virtual world. The labs may also double up as a social area to allow students to meet.

3.3.6.3 Library

The library or similar facility may offer an opportunity to add in much of the electronic learning material that is available today. This could be: electronic books, journals or any other material in written form, it may be videos and animation, it may be past exams that the designer of the environment wants to make available for the students, these may be all types of exams, both new and old. It may be all other types of traditional or non-traditional learning materials available from the designers of the system that they feel would be of benefit to the students.

3.4 Selection of development platform

The identification of a platform for development of a games based learning environment was done in by firstly identifying the necessary and desired features such a platform must/should support. From the perspective of the research the interest is in designing a model for an online games-based learning environment using narrative models, which will then be developed as exemplars of this particular approach.

Different types of development platforms can be used for implementing learning material in a games format. This investigation divided them into four groups, the investigation of each group is presented below. The four groups are:

- Existing virtual learning environments
- Game with the inbuilt editing/user created content
- Games engines

- Standard development platforms

The requirements for a game based learning environment varies depending on the type and level of learning that are to be supported, the current investigation focuses on support for a cooperative, constructivist learning environment suited for use in higher education. A list of the basic requirements is outlined below:

- Information and communication
    - Database
    - Network
- Games elements
    - The creation of quests
    - Dialogue with NPC (Non Player Characters)
    - Area editor / Landscape
    - Exterior architecture (buildings and other exterior items)
    - Interior architecture (items used in learning activities)
- Assessment
    - Support for both formative and summative assessment
    - Automated assessment and reassessment
    - Support of all assessment types, also essay style questions.
    - Feedback to students after assessment, what is correct and what learning material should be re-examined before attempting reassessment.

In addition to supporting these basic requirements listed above, a more specific support is desired. The requirements listed blow covers these more specific and games oriented requirements:

- Socialisation
  - Multiuser
  - Group activities
- Keep track
  - Log of activity
  - Log of progress
  - Experience points, can be used to track game progress and/or control access to different levels. This can then be utilised if needed for tracking gaming progress as opposed to progression through the learning material.
- Items
  - Different ways to gain and loose
  - Overview and maintenance of an inventory
  - Ability for the scripts to remove and/or change items players has in their inventory
  - Money or equivalent
  - The ability to craft new items, change one or more items into a new item.

During the consideration of the different development platforms support for multiple hardware/operating systems like, MS Windows, Mac OS and Linux are considered a

clear advantage. Different institutions and user groups throughout the educational community currently use different platforms, with Ms Windows, Mac OS and Linux being the most prevalent, and the more diverse runtime environments that the games based learning environment supports the better.

3.4.1 Existing virtual learning environments

The first group of possible development platforms investigated was Moodle[53] and Blackboard[52]. Moodle is a virtual learning environment programmed in PHP released as free software under GPL v2 license[113]. Blackboard is not free software but does offer the possibility of adding modules created in the Java programming language.

Early in the investigation it became clear that offering a graphical environment with anything resembling the richness needed to fulfil the elements described in the conceptual design is impossible within the above environments as they are formed today. The only solution to achieving the requirements would be to rewrite the VLE from scratch, alternatively small games can be added to a VLE., This first solution would negate the help using an existing VLE gives. This second solution would offer a graphical interface for the learning content inside the particular games, but it would be seen as separate from the VLE. This solution would then create a VLE with games added to it and not a game based VLE as was specified by the requirements.

3.4.2 Game with the inbuilt editing/user created content

Some games released come with an inbuilt facility for the users to create their own content, and additions to the game. Other games are picked apart by the users and fan sites appear with user created content, with or without the original creators consent.

An investigation into the utilisation of these types of games as a basis or the games based VLE was carried out.

The game system Neverwinter nights[114] was investigated as one example of the types of game that comes with inbuilt editor for user created content. At time of investigation (2004) Neverwinter nights is a popular and much used games platform, available on both MS windows and Apple Mac. First person shooter (FPS) games, of which Doom[115] is an prime example, was also investigated. These FPS games often have the ability to load specialised setup files at the start in the case of Doom these are known as WAD files[116]. These configuration files give the specification of items, map layout, graphical design of the environment and so on. DOOM is available on all the considered platforms, MS Windows, Apple Mac and Linux.

User created games or add-ons are relatively easy and quick to produce and give a lot of features with very little effort from the author. The investigation into the possibility to using games like Neverwinter nights or Doom as a learning platform showed however that they do not allow enough freedom in the creation of learning material. All information about the game progress is stored in a proprietary database with little or no access.

3.4.3 Games engines

The games engines that was considered as a basis for the learning environment was: Quake[115], Quake 2[115], Ogre3D[117], Torque games engine[118], Instinct Studio[119] and in the later stages MMOWorkshop[120] which is an add-on to the Torque games engine.

The initial investigation into all the engines revealed that two of the engines Quake and Quake 2 though they are free to acquire do not have a sufficiently large user community, commercial support for development exists but is costly. The investigation into Instinct Studio showed that this games engine does not offer any support for network and communication, the effort of creating a network module to be incorporated into the engine are well beyond the effort available for development in this PhD and Instinct Studio was removed from the list of engines to investigate further.

In the second part of the investigation small test applications were created in the two remaining engines: Torque and Ogre3D. Both of these have a significant user group and support are available for both. Ogre3D is released under LGPL[121] and is free to use, Torque has 100US$ license fee. The Torque Games engine was provided free of charge for the work done for this PhD.

A small test application was created for both engines. An external landscape was created with a few small huts, a lake, and items that could be picked up. Two avatars (players) logged on and both could see the other player, no other communication was implemented. Both tests ran satisfactory, the Torque version was tested with two MS Windows PCs as well as with one Mac and one MS Windows PC.

During the testing phase several add-ons to both Torque and Ogre3D were investigated, most of these add-ons lacked any community for development and maintenance. Only one of the investigated add-ons seemed to have an active and strong community, which is an essential part when no other support is available: The Torque MMO Kit[120] initially created by Prairie Games Inc for commercial purpose

has been opened up to a community and are maintained and developed by a group of users under a open source licence. The Torque MMO Kit offers a sample MMORPG world complete with scripting capabilities, inventory control and most of the facilities outlined at the beginning of the investigation, the only significant support missing is in the area of assessment.

3.4.4 Standard development platforms

As part for the investigation into development platforms for a games based VLE it was also considered to develop the software from scratch on a standard software platform. The platforms investigated was Java 3D[122, 123] and OpenGL[124]. During the investigation it soon became apparent that the amount of time and effort in creating even the small sample applications used as showcases for the technology was significant.

If the scope of the project permitted a complete development it would give a tailor made games based VLE with all the elements in the conceptual design. There would however still be issues about the deployment and spread of a new environment. Basing the development on something that has a user base and a community of developers that are familiar with the platform offers a future benefit in people to maintain and develop features and content.

3.5 Conclusions on development platform and further work

The findings in the literature review and the investigation and creation of the conceptual design has show that existing VLE technology is not rich enough to support the requirements for game-play of the types of games under investigation

giving the conclusion that such an environment would not be feasible. In addition the survey of games developed for learning suggests that many of these fail because of poor game-play and lack of environmental richness, so even if such an environment could be constructed it would not be effective. These findings show that, it is neither feasible nor effective to develop games-based learning activities using existing VLE and learning object technologies, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play.

Having showed that it is neither feasible nor effective to develop games-based learning activities using existing VLE, gives raise to another dimension in the research. That a methodology can be devised to incorporate learning activities and objects into existing games, with proven game-play, rendered within a games engine enhanced as a learning environment, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play.

The focus of the further work is then on how to best integrate learning content into computer games, what impact this integration of learning material this has on the game: does the game become less playable, do the students become de-motivated and any information that can be collected on level of engagement and reuse, and social interaction. An investigation on how to allow assessment to be an integral part of the learning environment is also part of the work that needs to be carried out.

The conclusion from the initial investigation was that a game based VLE cannot be based on any of the VLE investigated, neither can it be created with the use of the games offering up user created content, as this is to limited and there exists little or no

access to the database storing player information. The investigation on creating an environment from scratch using a standard development platform will require too much time and effort to be a viable option in the scope of this PhD. At the time of this investigation the Torque MMO Kit seems to offers the best development platform for a games based VLE.

The studies that are set up are designed to look for successful integration of learning material in a computer game, and then observing if the students reuse the game, cooperate, and socialise.

The studies will not be set up to test learning and retention, because it is known from learning theory that reuse and re-visitation on learning material enhances learning. The research focuses on investigating a model that will encourage a significant level of the students to return and reuse the game, and interact with the community of learners in the game. In terms of the actual learning outcomes, a further stage of this research having indentified what the best model for this integration, will be to conduct structured experiments or studies to test learning and retention, this second part are outside the scope of the work done for this thesis.

The series of studies that is planned are carried out in an attempt to investigate if a methodology can be devised to incorporate learning activities and objects into existing games, with proven game-play, rendered within a games engine enhanced as a learning environment, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play.

In total 4 prototypes was planned and tested.

Game 1: Take an existing game and layer the learning material on top.

Game 2: Take an existing game and embed the learning material into the game and make the learning material part of the game.

Game 3: Creating a built for purpose game where the game is built around the learning material and nothing else.

Game 4: Creating a built for purpose game where the learning material is abstracted out and the game is built around these abstracted elements.

The studies performed using the four games are described in chapter 5 through 9.

Assessment needs to be designed into the system to be an integral part of the learning process. The importance of having the assessment as an integral part and not something added just at the end are well documented.[21] Assessment is recommended to be built around essay style questions. Essay style question are good because they allow the student to demonstrate understanding. The value of essay style question and the students creating their own narrative are also well documented.[125]

Having selected a games engine for this development an investigation of which elements needed to support a learning environment that is not present showed that that main challenge was adding full assessment capabilities. In addition to adding full assessment capabilities, these capabilities needs to be automated and include automated assessment of student created narrative. The initial studies and the conclusion from this work are presented in chapter 4.

3.6 Development of the prototypes

The prototypes developed for the studies described in this thesis are online multi-user games where all the different players are present in the same virtual environment. The prototypes are based on the Torque game engine from Garage Games[118], in addition the Torque MMO Kit[120] initially created by Prairie Games Inc have been utilised. Torque MMO Kit is now maintained and developed by a group of users under an open source licence.

3.6.1 External tools

The Torque MMO Kit requires several servers to be setup and maintained. These servers are:

- SVN (Subversion): used for distribution of patches and updates to clients
- IRC(Internet Relay Chat): used for in game communication
- HTTP(Hypertext Transfer Protocol): used for information and initial place to download the client software. This server is also used by the SVN server for communication
- SMTP (Simple Mail Transfer Protocol): used to send e-mail, when users forget their password, and in the assessment part where submission of essays are required.

Torque games engine comes with a suite of tools to do landscape editing, placement of exterior artefacts and script behaviour and game-play, scripting is done in a language created by Garage games referred to as Torque Script. The Torque MMO kit contains a programming interface to the Torque games engine giving the developer the option of creating most of the code in Python[126]. The Torque MMO kit also

comes with a sample MMORPG application offering a starting point for the development of the prototypes.

A range of tools for creating jpeg and 3D-models was also utilised creating artwork that fits with the theme of the environment. During the prototypes presented in this thesis no new models were created, just altering models that were available. The effort required for creating all original artwork, both 2d and 3d, is substantial and was not a viable option in the scope of these prototypes.

3.6.2 Environment setup

The sample application contains a system for creation of users, the avatars for these users, and it maintains information about the individual avatars in a database. The setup is complex and includes several servers all running and performing different tasks while the game is running:

- Master or login server, maintains information on user logins.
- Character server, maintains and stores information about avatars, their experience points, gold and all other items. The accompanying database for this server contains the information later needed to verify progress and results of the students using the games based learning environment.
- World server stores and handles all information about ongoing players and communication between them.
- Zone servers, the world are divided into areas called zones, this is done to limit the amount of information one client has to handle at any time. As a users can only use one avatar at a time and this avatar are present in only one zone. A user will only have information about other players in the current zone they are in, thereby limiting the amount of information a client needs to handle

and the amount of network traffic between client and server. There is one zone server per zone. The zone servers are also responsible for all activities in the zone: NPC, dialogue, zone only communication, battles, etc

3.6.3 Alteration to the downloaded core code

Work done for this PhD included code produced that has been entered into the version available for download at www.mmoworkshop.com. The two pieces of code created for the community release are:

1. Data describing character models can be included as all the different formats that the Torque games engine accepts. Previously only one format was supported.
2. Dialogue of NPC used to only check player's inventory for items and do actions if they were present. The extension is that it can also perform specific actions if some or multiple items are missing.

3.6.4 Other alteration to the core code

The issue with all the investigated games engines was with support for assessment. For the games based VLE to be useable as a true VLE support for all types of assessment needs to be built in, in particular there is a need for essay style question and quick feedback.

Simple forms of assessment like multiple choice questions are an integral part of games engines. The Torque MMO Kit does also support more complex tasks, where multiple items can be used to create one or more new items. This is in MMORPG language referred to as crafting. However the identified assessment capabilities of this and most other games engines stops with crafting.

Chapter five describes an investigation into automated marking of narrative. The method investigated can either replace or support a solution of mailing the narrative to a human tutor to get it marked, The requirement for the environment to accept a narrative from the players are unaffected by this investigation. However the processes of supplying a quick feedback to the students will depend on an automated replay.

The solution for submission of narrative created was to create a screen page in the form of a dialogue window where the students could enter their created narrative. This narrative was then sent, by e-mail or forwarded to any other program on the server, along with relevant information about the player: player name, quest completed, quest attempted, relevant items from inventory, etc. E-mail address for the narrative and information included are configurable for each assessment instance.

3.6.5 Creating the prototypes

A series of prototypes was planned, each of them followed a standard development routine once the learning content and overall desired feel of the environment was decided..

1. Create landscape with textures
2. Place external architecture
3. Create start point for the user avatars
4. Create items that are needed
5. Implement behaviour of items and recipes that can be used to transform them
6. Place NPC
7. Create and implement the dialogue for the NPC
8. Create and implement the behaviours of NPC

Naturally a great deal of trial and error and testing are performed to verify the placement and behaviour of all elements in the environment during the development. There is also a natural loop of the activities 6 through 8 that needs to be performed multiple times to get all NPC correctly placed and function as desired.

3.6.5.1 Landscape

First the landscape was created the elevation of different points needs to be set valleys, mountains, hills and flatland are created. This work is done using the landscape editor that is part of the Torque Games engine.

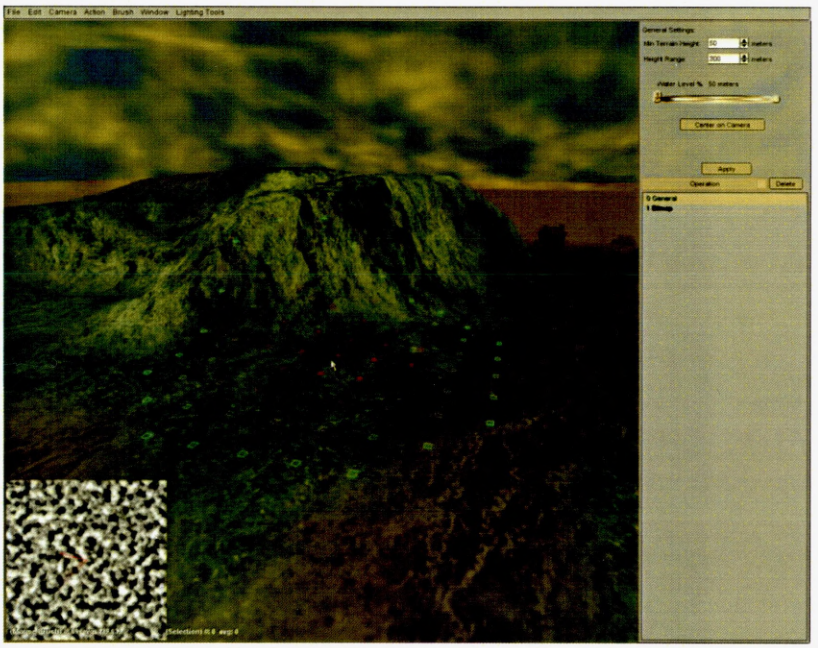

Figure 3-1 Landscape editing

Then the textures of different parts of the landscape were set. The textures utilised mostly can be seen in the top right corner of the screen shot.

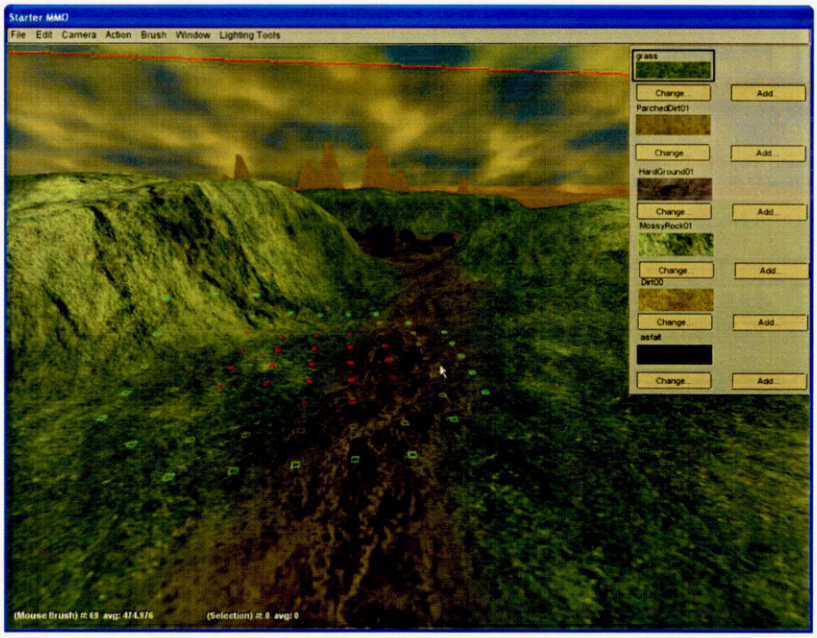

Figure 3-2 Texturing the landscape

3.6.5.2 Placement of external architecture and NPC

The placement of all external architecture and start points for players and all NPC are the next tasks to be done. These elements all have a location, scale, rotation, names used to access them from the script code, in addition to many other parameters.

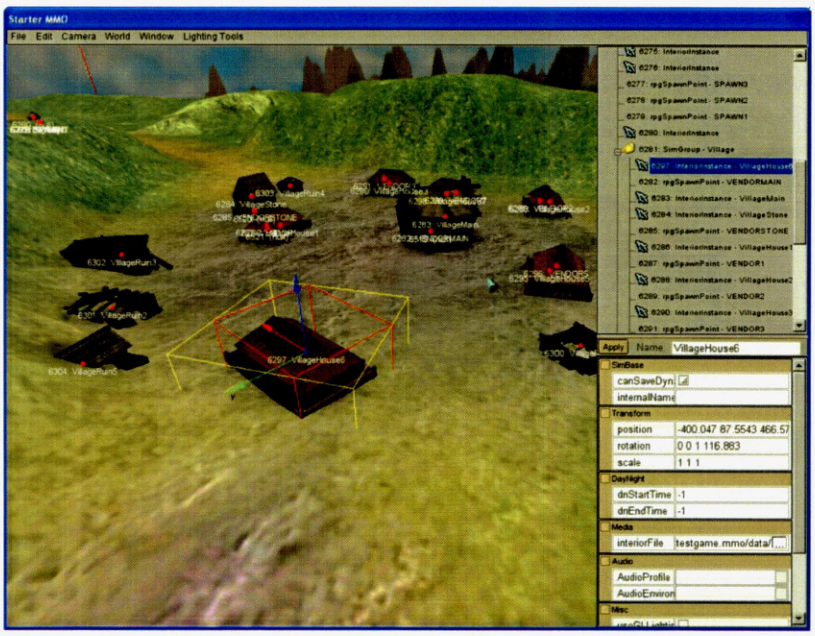

Figure 3-3 Placement of elements in the world

3.6.5.3 Dialogue and Game logic

All dialogue and the behaviour of NPC, game logic and items are created using Python script code. The graphical editor can place NPC in the game area but they will just look and behave as statues unless they are given dialogue and behaviour. Early in the development work for the prototypes some simple templates for dialogue, items, and NPC creation was created. These templates are included in appendix A.

The main challenge in the development of the prototypes is not the creation of the individual elements but rather the interconnection of all the elements and the sheer number of different elements that needs to be created. There are also issues of the individual identification of so many elements in both the 3d editor and in the script code, and the matching of names from one to the other. As an example a NPC will have:

1. Name
2. Spawn Name
3. Spawn Group Name
4. Dialogue Name
5. Trainer Name
6. Vendor Name

All of the names above need to be unique names for each NPC and needs to be matched up with the correct element. The result of all this is that the work requires meticulous planning and concentration all through the implementation phase, as a couple of the prototypes contains in the excess of 100 NPC.

The learning content is integrated into the game elements differently in the different prototypes and are described in each of the studies.

3.6.5.4 Deployment and Creating client

After the prototypes are created they are packaged into an executable file with an accompanying installer ready to be downloaded by the users. This executable file is made available via the Web server.

The only activity that needs to be performed then is to start all the different servers that make up the environment, so that users can connect, learn and interact.

3.6.6 Scripts to list logged data

The environment does as previous mentioned log data. Most of this data are for game purposes but it can also be used to track the users' progression through the learning material.

The initial database setup is part of the Torque MMO Kit and data are not stored in a manner that makes it easy to access. In order to access the data a few scripts have been created, these include "Getting data from one character database" and "Getting data on player progress from one character database per day in the prototypes" these scripts are included in Appendix B.

4 A consideration of the use of plagiarism tools for automated evaluation of Student-created Narrative-based Assessment

The topic of this chapter is the description of a method for assessment called "Student-created Narrative-based Assessment" and a report of an experiment on the consideration of using plagiarism tools for automatically evaluating the student responses.

The assessment approach described here and previously published[5] differs from traditional narrative based assessment. It provides a support mechanism for the student in their skills in narrative construction, and formatively feedback information to aid the students to discover the conceptual linkages between the elements of information that they have gained within the context of the topic they are studying. This provides a view of how the student is constructing their learning. The use of student-created narrative-based assessment also assists the student in learning and developing their understanding.

The proposed assessment system is intended to be implemented as part of a learning environment with focus on the utilisation of a game based model. When this proposed method is used for summative assessment with feedback it can also be used formatively by the student to continue to develop their understanding until they reach a point when they achieve a required threshold. This feedback can be used to guide both the students and the systems responses to the student's actions. The student is in control of the process and may progress when the required level set by the system is

reached or postpone the progression until they are satisfied with their own level of understanding.

The assessment of a narrative is a time consuming task and students immersed in a games environment require fast feedback. The mechanisms to provide this fast feedback within the system needs to be based on automated assessment. An experiment using plagiarism detection software for automated assessment has been run and is described later in this chapter.

The assessment approach described here and previously published as [5] "Student-created Narrative-based Assessment" at E-Learn 2006, in Honolulu USA. And the investigation in this chapter with results have previously been presented as [6] "A consideration of the use of plagiarism tools for automated student assessment" in IEEE Transactions on Education, 2008.

4.1.1 Student created narrative based assessment

The student created narrative based assessment is based on the student demonstrating their understanding of a topic by creating a narrative. That narrative usually takes the form of the exposition of a series of facts and the relationship between them, as a means of describing the overall conceptual view of the topic under consideration. The basis for this is how the student is constructing their learning. The use of student created narrative based assessment is assessing how the student is obtaining learning and developing understating.

Each piece of learning that the student is undertaking is part of the overall picture. The students are presented elements and concept, as the outcomes of quests, and ask

them to combine these elements into a narrative. The result of this is that the narrative is not used as a demonstration of the knowledge the student already possess, but the narrative is the means by which they develop the understanding of how those concepts interrelate. The creation of the narrative actually builds the understanding, and it will also demonstrate that the learning has taken place.

Narrative in its structure is a good way of demonstrating understanding, any help to the students to create the narrative themselves will aid in the learning process. This help in creating the narrative is an important part of the learning process and will gradually be fading as the students are creating their own understanding. Any help given to the students during the creation of the narrative will be in the form of scaffolding. This scaffolding will aid the students in the learning process as they are creating the narrative, which is an important part of the learning process and will gradually be fading as the students own understanding increases. The scaffolding put into the learning material to help in the initial phases of narrative construction should guide the students around any major pitfalls they are likely to encounter in creating their narrative and save them from making too many erroneous connections in the early learning phase.

It is not a discussion of the student understanding narrative written by others, the aim is for the student to genuinely construct their own narrative. The authors of the learning material must be aware of this when offering scaffolding to aid in the student's creation of narrative. Tracking a student's progress through a games based environment can be used to verify that the student presents their own narrative and not a narrative produced by somebody else.

After the created narrative is complete it will be assessed in term of its contextual description and relevance, it will demonstrate if the learning has taken place. The use of narrative assessment is a good way of demonstrating understanding. The mechanism that we seek to use, the essay or discursive text, to describe our understanding, has its foundations in the Greek and Roman traditions. A modern description, argument and history of writing as assessment is given by Hamp-Lyons.[127]

It is important to note that the basis for the student created narrative based assessment are not about the students understanding or memorising the narrative written by others, they are to genuinely construct their own narrative. The authors of the learning material must be aware of this when offering scaffolding to aid in the student's creation of their own narrative.

The assessment of a narrative is a time consuming task and students immersed into an environment, such as a proposed game based environment require fast feedback. To accommodate this there is a need to include mechanisms for automated assessment into the virtual learning. Various forms of automatic assessment have been carried out with varying success over years [128, 129]. Assessments using multiple choice questions, point and click interface, diagrams or mathematical expressions are examples of automated assessment that have been successful. Automated assessment of discursive or essays solutions however are not as straight forward. Research into involving computers in assessment started in the early 1960s. More recent research, have addressed the automatic grading of essays [130-136], some of the methods used

previously have in more recent times been used as the basis for some plagiarism detection tools, this led to the investigation of a possible new use of these tools. The proposed basis for developing automated assessment and fast feedback is the utilisation of grading of student work using tools developed for plagiarism detection.

4.1.2 The basis of narrative based assessment

Traditional essay style assessment is based on the students constructing and developing their learning over a period of time and they are then placed into a situation where they are required to demonstrate that this learning have taken place over a short period of time. The assessment is performed after the learning has taken place and is not integrated into the learning process. In the proposed student created narrative based assessment the creation of the narrative by the student is seen as an integral part of the learning process. As noted earlier, assessment should be an on-going process aimed at understanding and improving student learning, not something added at the end.

One of the key concepts in student-created narrative is that, during the creation and development of a narrative the students are developing their understanding, in addition the resulting narrative can be used to demonstrate understanding of the topic area and thereby prove that learning has taken place. The assessment model does not pose any time limit on the students, neither is it imposing any limit on number of attempts. Students are allowed to use the feedback from the assessment of their constructed narrative in a formative fashion if that is their desired learning strategy.

The proposed solution to the problem of asking students to produce essays on demand is by assisting the students in creating a coherent narrative during the learning to

demonstrate that the learning have taken place. This is the distinct differences between student-created narrative based assessment and traditional essay style questions, though they both are based on the notion of students creating essays to demonstrate that learning has taken place. The description is then of something more than the traditional essays questions and the addition is not in technology or environment e.g. essay style questions online etc. What the concern is that in creating a narrative, a student has to be able to understand their topic and they have to be able to express this understanding. The creation of this narrative is a supported constructivist process, with scaffolding that gradually fade as the student progress up the levels and narrative that are adapted to the concepts being assessed. Narrative as understood in this is, a mathematical expression, a storyboard, a diagram or an essay, are an excellent way to demonstrate conceptual understanding.

4.1.3 Narrative based assessment in a games environment

The aim is for the student progressing through the gaming concepts gain understanding in a constructivist and exploratory model, the authors argues that this is inherent in MMORPG games, in that they allow just such exploration and freedom. A MMORPG typically offers the player a number of options like available paths and environments to explore and different quests to attempt. The students are then faced with a construction of a narrative in a constructivist fashion, with scaffolding that gradually fade as the student progress up the levels and narrative that is adapted to the concepts that are assessed. Showing students the entrance and then letting them get on with their learning is not an efficient or even sensible strategy for education, so new students in the system will need to be guided and led, while maintaining enough freedom to allow them to explore and direct their own learning.

The student will collect a number of items or concepts during the learning phase. When they have collected the required or desired number of elements/concepts, and have acquired an understanding of the context of these elements and how they fit together, they will progress and attempt to complete the assessment. The students are free to explore the environment in any order they like. The elements/concepts that the student are requires to collect and understand, does not have to be collected in any specific order. The context is where and how the collected items and concepts are found and are the basis for how these are to be understood, and later used to demonstrate this understanding in the constructed narrative. The created narrative may require more elements than they have collected, particularly in scenarios where the students are allowed entry into the assessment without the requirement to complete all quests. In addition it will present them with challenge of combining the elements they have collected into a coherent narrative.

The assessment is divided into two parts. The first part is to help the student to construct a narrative, the environment will in this phase support the student. The student is supported via scaffolding this means that they are given controlled help and possibly a structure where they can fit the previously collected concepts together. Depending on which level the student has progressed to within the game, the amount of support provided is going to vary. In the early stages/levels support will be plentiful, as the student progress the support will fade and at the last stages may be completely removed. In the early levels the focus will be to teach the student how to construct a narrative, and it is therefore a necessity to keep the requirements of the created narrative simple in this phase. The help provided to the student will be to

identify the important concepts and how to construct an argument, how the information interrelates and how to then sequence the information into the constructed narrative. All this support information can be modelled as standard learning material, i.e. in a quest form, inside the assessment part of the environment. After the student has explored this supporting learning material on how to create a narrative and is ready to complete the assessment exercise proper, they will step into the final part where the assessment will be done. Into this final stage only the items/concept collected during the quests will be allowed. The task set to the student will be to use the elements that they bring with them and arrange them into whatever the task specifies: a model, an equation, an essay or whatever the assessment requires. The previous given support on how to create a narrative in this particular assessment will guide the student to the appropriate form of narrative. In the cases where the students have completed only a number of quests and not collected all available concepts and items available to them in the game, the designer of the task will have to make a decision on how this is to be handled.

4.1.4 Assessing the constructed narrative

The assessment of a narrative is a time consuming task and students immersed into an environment, such as a games environment requires fast feedback to maintain a state of flow[104], "have I understood this, passed the test and able to continue or not?" To accommodate this there is a need to build in mechanisms for automated assessment into the virtual learning environment.

Automated verification of solutions created by the students can be hard or reasonably straight forward depending on the type of solution expected. In this case an automated assessment of discursive or essays solutions are the target, as described earlier this is

not straight forward. The proposed basis for the described investigation is developing automated assessment and fast feedback of student work using tools developed for plagiarism detection.

There will be instances where the expectation is for the student to present a narrative that contains items/concepts in a specific context and in a certain order, because the concepts have a relationship with one another. Some of the concepts that the student is expected to present will have a fixed relationship and the order is important, others will have a more free form and must be allowed in a variety of orders. The context of concepts presented to the students in the earlier quest/ learning material will influence how they incorporate them into their constructed narrative, but the assessment system must not require this to be the case. Unless the contexts in which these concepts are presented are the only valid, other contexts must be allowed.

The algorithms utilised are published either as open-source or/free tools, an overview of available tools have been produced by Lancaster and Culwin[137, 138]. There are several clear advantages with working with open tools, the first is that in the proposed environment we will utilise these plagiarism detection algorithms and tools in a new and not by the original designers intended fashion. Free open tools do publish the criteria selection for the metrics they utilise for assessing the written essays, this also provides the confidence needed for the automated assessment.

To be able to produce a result with a high degree of certainty, the system will need to use more than one set of plagiarism algorithms.

- One set of algorithms used will need to be based on structural metrics, where the documents first are tokenised. The process of tokenisation takes the form of removing as much of the unnecessary information and "fill" text as possible from the students submission. The processing of the text will involve identifying a set of words, expressions and concepts and substituting these with tokens. The next step in the process will involve the comparison of chains of these tokens with previously prepared targets. The number and length of token chains found to be equal to the target token chains will give a measure of how close the student created narrative are to the target.
- One variation of the token algorithms described above would be to perform the same comparison described on the chains of tokens on an untokenised text, in this case the comparison would be finding runs of similar words. To create a better chance of detecting similarities the text would need to be pre-prepared to remove spelling errors, grammatical errors and other factors that have not influenced the degree of understating demonstrated by the student.
- One other set of algorithms used to grade the student created narrative can be standard grammatical analysers similar to one found in word processors. These algorithms can verify that the text produced by the students is a full text and not just listings of words and concepts encountered though the learning process. Another source of tools to verify that the narrative produces meets with a minimum set of requirements to be considered, is general essay assessment tools[127, 135, 139].

There are multiple tools to detect plagiarism and the performed investigation have been investigating two set of tools that are widely in use The tools chosen were

TurnItIn[140], a commercial tool provided to the UK Higher Education community by JISC, and VALT/VAST, a set of tools created at "Centre for Interactive Systems Engineering" the workings of which are based on recognised and well published research[137, 141] VAST is primarily used to investigate two documents and trace out the similarities within them. The tool works with words both sequenced and unsequenced, and produce metrics on both. The visualisation part of the tool will not be utilised in the games environment but the metrics will be of great value in determining the degree of understanding demonstrated by the student.

4.1.5 Findings from investigation into automated assessment using plagiarism tools

The results obtained and presented in[6] show no correlations found with the VALT/VAST and only trivial correlation found with TurnItIn. These findings hold both between sample solution and student solutions and within the individual student solutions.

This is only a small sample set and the answers generated by the students where overall relatively short. However the fact that there are no correlations between sample solutions and student solutions nor any correlation within the individual student solutions suggest that these text analysis plagiarism tools are to firmly focused on direct copy, and don't provide enough richness and fuzziness for us to use them for our purpose. Clearly the use of our proposed prototype, where the students select the time of assessment, might result in the students generating longer narratives. While this might potentially be thought to be valuable in providing the plagiarism tools with more text to analyse, given the fact that the student solutions in the investigation are all of a similar size, style and shape and the tools did not find any correlation between

them suggest that these tools are of little value for automated assessment of narrative in a games environment.

The tools investigated do not offer enough richness and fuzziness to discover a sophisticated plagiarism attempt, where a text is copied and then some words replaced and altered without altering the content, for example using text replacement tools to change terms and obfuscate a plagiarised text. In the longer term, a close relationship between research in automated assessment and plagiarism detection could offer considerable benefits to both areas.

5 Study one – Layering: Learning content is added on top of a game

This chapter describes the first prototype implementation of a design for a game based virtual learning environment, The design is previously published[4] and described in chapter 3. The study is performed by developing a prototype which is then tested using a group of first year students learning Java programming at University of Abertay Dundee. The students testing the prototype is referred to as participants in the rest of the chapter.

The prototype is created with a minimum of effort. The learning material is just added on top of an existing games implementation resulting in the least amount of work. No effort was made to integrate the learning content into the existing game, other than answering questions connected to the learning material gave the participants useful items in game.

The focus of the testing is to determine the viability of a muli-level, multi-player gaming environment as a learning environment and to determine the issues in developing and presenting learning material within the environment. As part of the study the participants were also asked whether they feel playing the game improved their knowledge, if they enjoy this form of learning, and if they find it useful. Our aim was also to examine to what extent the participants help each other during the game, since MMORPG environments are known for their ability to create online communities, in which mutual help cultures amongst players are emergent.

The study in this chapter with results have previously been presented as[7] "Prototyping a Games-Based Environment for Learning" at E-Learn 2009, in Las Vegas USA.

5.1 Games based environment for "Methods in Java"

The prototype was created for an introductory module in Java programming. The lecturer of the module had previously identified methods as an area where students in previous years were struggling and any additional ways of presenting this material would be beneficial.

The main question the study was set up to investigate: Is a games-based environment a viable way to present learning material? In addition the study contributed to the overall question: What level of embedding of that material is necessary within a game?

The aim of the prototype is also to gain information on:

- How much effort is required from the participants before they can use this environment for learning?
- Do the participants feel playing the game improved their knowledge?
- Do they enjoy this form of learning, and do they find it useful?
- How much did the participants help each other during the study?

5.2 Content

The game for presenting methods in Java is the first prototype implemented from the previously published design[4]. Because of this it was decided not to make it overly complex and focus on a limited playing area and learning material. The environment

is implemented as one large grassy valley, using the walls of the valley to stop the players from moving outside the area where the learning content is modelled.

5.2.1 Design of the environment

The playing area is divided into several minor areas, which the participants are free to move between. These subdivisions are intended aid the participants in navigation and not to limit their movement in any way. A schematic map of the environment is shown in figure 5-1. The minor areas shown on this map are: Staring point (figure 5-2), a village, two farms, an Aztec pyramid, a single farm and a plateau.

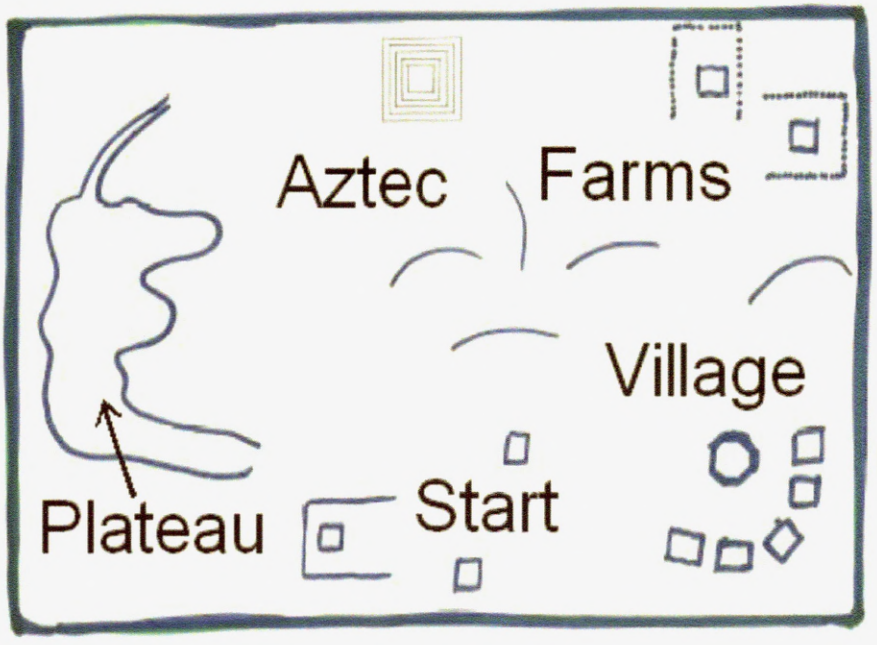

Figure 5-1 Map of the playing area in the first prototype

Figure 5-2 Screenshot of the start on the first prototype

The playing area is modelled with several types of building, the type of building identifying the area the participants is in. Shown in figure 5-2 is a standard two storey house typical for the starting area.

Within each area there are a number of non player characters (NPC) for the participants to interact with. These NPC can all be interacted with, and come in the three categories: Allied, Neutral and Enemy. Enemies show up as red on the included map, top left corner in figure 5-2, and are an integral part of the gaming experience, the other types of NPC are equally important and are there to be interacted with by dialogue and not fighting. The Neutral NPC's generally gives the students quests, information about Java or hints how to progress in the quests.

NPC as allies are mainly present in the environment so the participants can run to somebody for help fighting enemies too strong for them. E.g. there are a number of

tigers around the Aztec pyramid that will attack on sight, but in a nearby farm there are a pack of dogs that will attack the tigers if you run there for help when the tigers attack. The NPC living in the farm will tell you this if you have interacted with her, if not you will probably die and be sent back to the starting point. On death, a participant does not lose any of the items they have accumulated and all completed quests are still completed.

Some neutral NPC's are helpers, they will help participants move through the environment, and they all provide simple adaptive frequently asked questions (FAQ) facility and will attempt to tailor their help according to the participant's level of progression through the quests.

Other neutral NPC's are quizzers, and have questions on themes related to Methods in Java. These questions are in a multiple choice format. When interacting with the NPC it will present the question, as demonstrated in figure 5-3, the participants will only have the possibility to attempt each question once. If the participants turn away or choose not to answer, they have the option of coming back and answering another time. A correct answer is rewarded by an item and all Quizzer NPC carry unique items. If a question is answered incorrectly the question is no longer available, and the item that NPC carries can no longer be obtained by that participant. The items that can be obtained are different types of armour and weapons: helmet, gloves, shields, swords, legging, boots, body, and so on, in different strengths. These items make exploring the environment easier and give the participants the possibility to fight the various enemies, see figure 5-4.

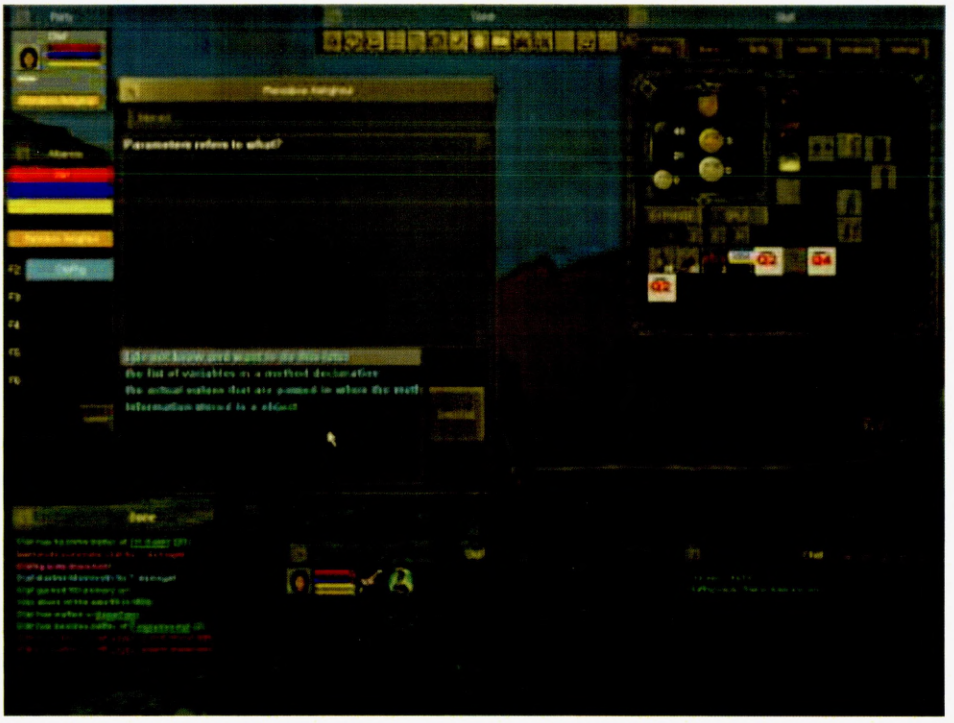

Figure 5-3 Interacting with NPC on the first prototype

Figure 5-4 Fighting an angry mammoth in the first prototype

Figure 5-5 Interacting with other players in the first prototype

Social interaction is an integral part of the environment, there are two main ways for participants to interact with other participants in the environment, these are the two usual ways used in all MMORPG type environments, chat and trading. The chat system contains several channels dealing with: participants close by, participants in the same area, all participants, a help channel, and an off topic channel for all communication not directly linked to the environment and learning. The chat window is seen in all the screenshots as the window on lower right part of the screen in figure 5-2 to 5-5. Trading is an option for participants to buy and sell different items, seen in figure 5-5. Not all items are allowed to be bought and sold, this is set by the designer of a level and in this particular case no items of armour or quest linked items can be bought or sold. The reason for this restrictive practice is that it is the possession of these items that is used to track the progress of the participants through the environment.

5.2.2 Learning content in the environment

The different quests in this first prototype are not directly linked to knowledge of Java. Though they are indirectly linked, some of the quests require the participants to first acquire some armour and weapons and then to successfully fight and obtain, from some enemy, something a NPC requires for completion of a quest. The outcomes of the quests are information that the participants can use to successfully answer the questions set by the Quizzer NPCs, thereby obtaining better armour and weapons, and make future exploration and quests easier. The questions set by the Quizzer NPCs are learning material specific, so although the participants did not require specific knowledge of Java to undertake the quests, they need Java information to progress.

The learning content is divided into four quests. These four quests can be completed in any order allowing the participants the freedom to explore the environment and deal with the quests as they discover them

- Quest one: Naming a Method
- Quest two: Passing Information to a Method
- Quest three: Passing multiple pieces of information to a Method
- Quest four: Controlling Access to Members of a Class
- Final assessment

Completion of all quests is required to access the final assessment, which is in the form of a student created narrative. Student created narrative based assessment[5] is based on a participant demonstrating their understanding of a topic by creating a narrative. This narrative takes the form of the exposition of a series of facts and the

relationship between them, as a means of describing the overall conceptual view of the topic under consideration. In this case the students are asked to link the concepts: Methods, used for, used by, class, object, type, void, int, access modifiers, parameters, values passed, values received, body. The assessment of this participants created narrative is carried out manually. After the participant's creation of a narrative, it is sent by the environment via e-mail to a tutor for marking.

The knowledge that is required to successfully answer to the questions, both the NPC's and the final assessment can be found within the environment, but can equally well be obtained by any other source, text book, internet fellow student online or offline. The aim of the environment is not to control where the participants are obtaining the knowledge, just to aid them in learning.

5.3 Trials

A group of about 70 students doing a module on Java programming was offered the possibility to participate in the test of the environment. The test was introduced to the participants in a standard 2 hour tutorial. The participants were given a 10 minute introduction to the environment and how to navigate through it, in addition they were given a pre-questionnaire that took between 1 and 5 minutes to fill in. The rest of the two hour slot the participants were allowed to try out the environment on their own. Both the lecturer of the Java module and the developer of the environment were present to answer any questions.

A total of 56 students participated and filled in the pre-questionnaire, with over 50 participants completing the whole study. From observing the participants we noted that not all of them utilised the environment as planned, several were obviously used

to MMORPG style games and experimented to find inconsistencies, dead-ends, or simply fought all NPCs they could find. Generally there were no problems with this except in some rare instances where they managed to get NPC's essential for other participants to chase them for long distances and not be available for others to communicate with. This was easily sorted by making essential NPCs exceptionally strong and quick in later versions of the environment.

At the completion of the module, some weeks after the initial session, all the participants in the group were e-mailed a post-questionnaire and asked to answer it, several reminders later a total of 21 participants had responded, a 40% return on those who completed the study which represents are an acceptable return for a questionnaire.

5.4 Results

All questions on the questionnaire are on a 5 point Likert scale (Very little; Not much; Average; Quite a lot; Lots) giving the values from 1 to 5 in the tables. The questions and results for the pre questionnaire are:

	Average	Std dev
How would you rate your knowledge in programming so far	2,8	0,8
How would you rate your knowledge of methods in Java	2,5	0,7
How much do you enjoy programming	3,3	1,1
Have you any previous experience with computer games	4,0	1,2
How much do you enjoy playing computer games	4,3	1,0
Have you any previous experience with MMORPG	2,9	1,5
How much experience do you have with games designed for learning	2,1	0,9

Table 5-1 Results from pre questionnaire "Methods in Java"

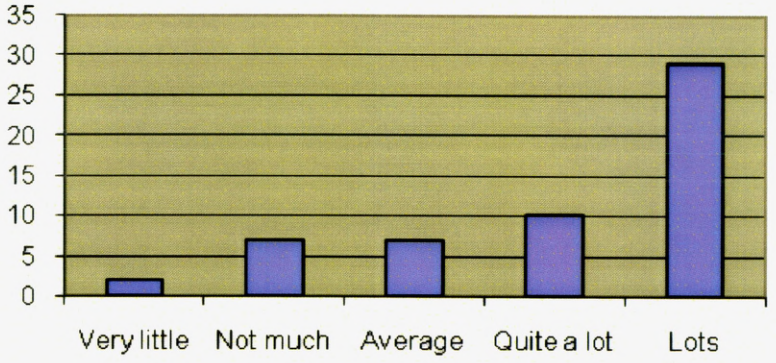

Figure 5-6 Previous experience with computer games

The results found from this is to be expected, they rank their knowledge on methods in Java as average, they enjoy programming, enjoy computer games even more and have a limited experience of computer games designed for learning.

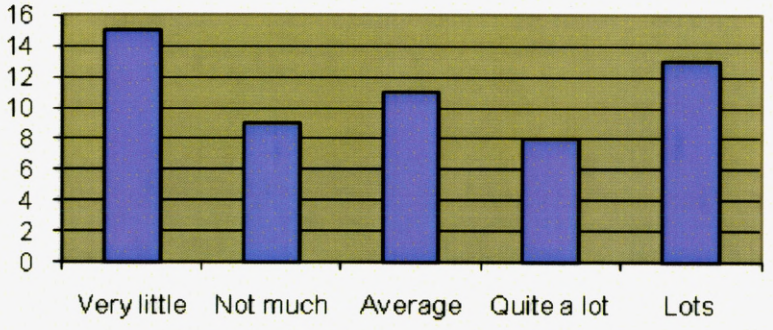

Figure 5-7 Previous experience with MMORPG

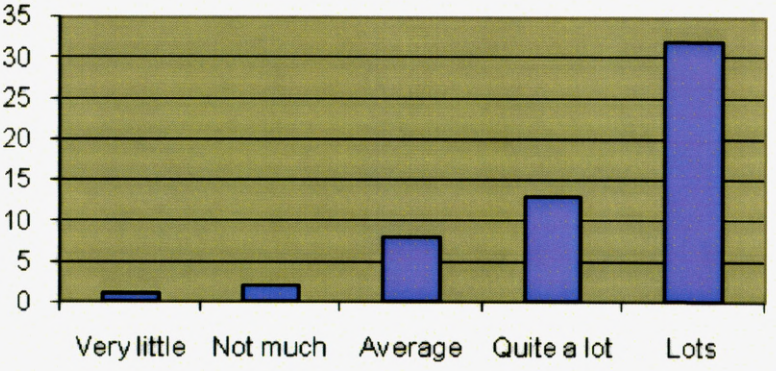

Figure 5-8 Enjoyment of playing computer games

The post questionnaire was only received from 21 participants. The participants were required to put their chosen login name on the questionnaires in an attempt to track the students, however only 8 students gave the same name at the pre and post-questionnaire, so there was no real potential to cross-reference. The questions and results of the post-questionnaire are:

	Average	Std dev
Do you feel playing the game improved your knowledge of methods in Java?	2,0	0,7
Did the game give you any benefit compared to traditional lecture/lab	1,8	0,7
How much did you enjoy playing the game	3,0	1,0
How much did other students help you during the game	2,5	1,4
Did you have any difficulty navigating the game	3,0	1,5
How important was the introduction by the lecturer before playing the game	3,3	1,2
Having played the game how useful do you think games like this are for learning	2,5	1,7

Table 5-2 Results from post questionnaire "Methods in Java"

The participants were also asked how much time they spend learning the environment before they could use the environment. The detailed results are shown in Figure 5-10.

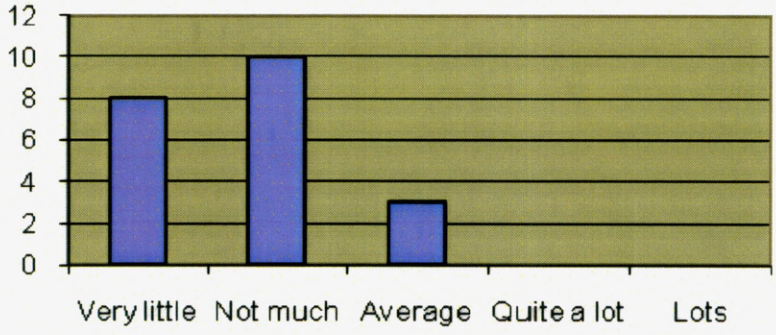

Figure 5-9 Benefit using the environment

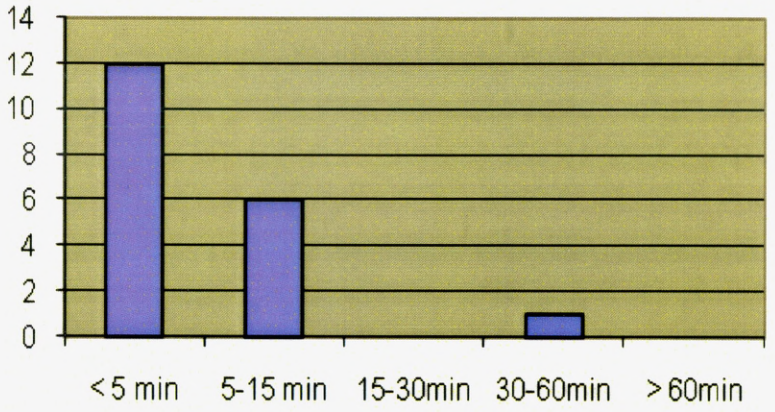

Figure 5-10 Time spend learning the environment

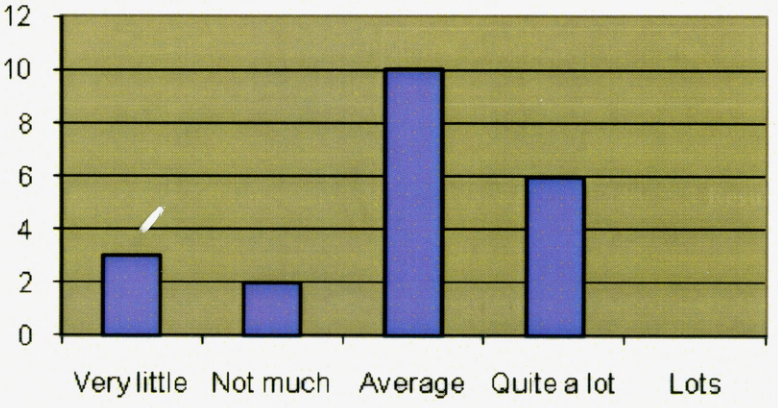

Figure 5-11 Enjoyment on using the environment

In addition to the questions the participants were also given the option to comment. These comments point out a few issues that have to be improved in future versions of the environment.

- The participants are not happy with the movement speed too much time is spent walking from one place to the next.
- The Quizzing NPC did not give a good enough explanation when the student answered wrongly on a question, some did not give any explanation.
- There are also comments that the quests are not connected to learning Java.

The study did also gather information on when the participants logged in to the environment, going through this information the statistics show that none of the participants used the environment after the initial two hour session.

5.5 Initial conclusions from the study

The design of the study describes the decisions taken in developing the trial game to layer learning material on top of existing game-play, to test whether such an approach was acceptable to participants. The feedback from the participants demonstrated that they enjoyed and engaged with the game-play aspects of the game, but found the layering of learning material to be intrusive and this detracted from their enjoyment of the game.

From observing the participants it was noted that some of them utilised the environment differently than was intended. Several participants were obviously used to MMORPG style games and utilised the trial time in the study to find inconsistencies, dead-ends, and generally fought all NPCs they could find. This was an unforeseen activity by the participants and needs to be discouraged in future studies. The problem can be easily rectified by making essential NPCs exceptionally strong and quick, so players attacking them simply die and are sent back to the start of the game.

The findings of this study will be utilised in the next study. The main finding is that layering learning material on top of existing game-play without any relationship to that game-play does not work and detracts from the enjoyment of the game. This suggests that the learning material needs to be more integral to the game-play and the

learning activities need to be related to game activities, and the next study will utilise a game addressing these points.

6 Study two - Embedding: Learning content is modelled as quests into a game

This chapter describes the second prototype implemented from the design for a game based virtual learning environment, previously published[4] and described design in chapter 3. This prototype is then tested using a group of first year students learning C++ programming at University of Abertay Dundee, the students testing the prototype is referred to as the participants in the rest of the chapter.

The focus of the study described here follows on from study one, learning content layered on top of a game, described in chapter 5. The main question this study is design to investigate: Is a games-based environment a viable way to present learning material, and what level of embedding of that material is necessary within the game? Particularly, to investigate what effect different levels of embedding of the learning material within the game context had on the player's perceptions of game-play and learning?

This study as with the other studies also designed to help determine the viability of a multi-level, multi-player gaming environment as a learning environment and to determine the issues in developing and presenting learning material within the environment. As part of the study we also asked whether students feel playing the game improved their knowledge, if they enjoy this form of learning, and if they find it useful. Our aim was also to examine how much time students used before they are capable of using the environment for learning and to what extent the students help each other during the game, since MMORPG environments are known for their ability

to create online communities, in which mutual help cultures amongst players are emergent.

The aim of this, as with all the prototypes is also to gain information on:

- How much effort/time is required from the students before they can use this environment for learning
- Do the students feel playing the game improved their knowledge, and does it actually improve their knowledge
- Do they enjoy this form of learning, and do they find it useful
- How much do the students help each other during the game

The aim of this prototype was also to gain information on of these questions:

- Were the improvements from the first prototype successful
- Is fighting necessary within an MMORPG environment to create enjoyment
- And as previously mentioned what effect different levels of embedding of the learning material within the game context had on the participant's perceptions of game-play and learning?

The study in this chapter with results have previously been presented as[8] "Prototyping Games-Based Environments for learning C++ programming "at HCI Educators 2009, in Dundee UK.

6.1 Games-based environment for "C++ programming"

The prototype described in this chapter was created specifically to be run as an addition to a first year course for Computer games students in C++ programming at University of Abertay in Dundee, Scotland. The lecturer for the module had expressed an interest in new ways of presenting material and giving the student the possibility to assess their own progression, and an extra opportunity to add content to their portfolio. The same prototype was also made available to students in Norway.

The participants testing the prototypes were a mix of students from University of Abertay in Dundee, Scotland and Buskerud University College, Norway. Both Universities offered lab facilities where the game-based VLE client was installed, and in addition all the participants had the option to download the client to their own laptops or home computers. A high percentage of the Norwegian participants opted for the latter option. The same server was used for all the trials, and is located in Norway.

6.2 Content

6.2.1 Design of the environment

The physical appearance of the environment used for the C++ was not the main issue and it was decided not to make it overly complex and just focus on a limited playing area and design a suitable range of quests. The virtual environment for C++ is build inside a valley and is made up of three levels: The initial level is the grassy floor of the valley; a plateau is level two; and finally a great building in the middle of the valley is level three. The whole environment is populated by around 120 NPCs, nearly all of them friendly, and in this environment there are no weapons or armour.

Learning from the trials of the first prototype where the participants complained that too much time was taken up by moving, we positioned the NPCs so that the distance needed to move was smaller, and, in addition, we increased the movement speed of the participant's avatar.

The playing area are divided into several minor areas, and the participants were free to move at will all over the playing area, so these subdivisions were created to aid the participants in navigation. A map of the environment is shown in figure 6-1. The minor areas shown on this map are: Starting point (figure 6-2), Village, two farms, an Aztec pyramid, a single farm, a plateau which is level two, and the great hall which is level three. Within each of these areas there was one quest, requiring the participants to prove their knowledge in C++. The knowledge participants are required to demonstrate may be obtained from helper NPCs within the game environment, or from any other source of their choice.

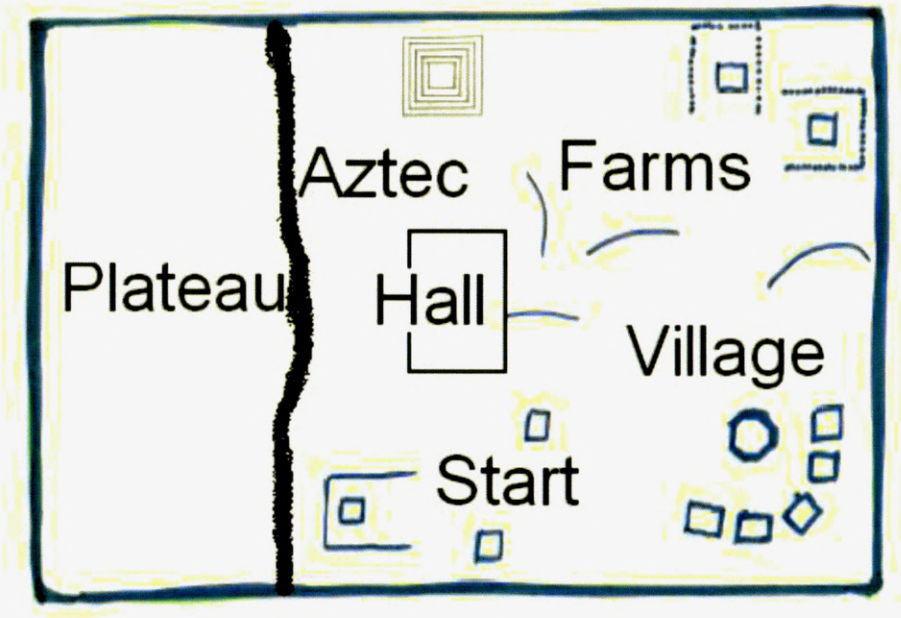

Figure 6-1 Map of the playing area

Figure 6-2 Screenshot of the start on the second prototype

Within each area there are a number of non player characters (NPCs). These NPCs can all be interacted with, and come in the three categories: helpers, quest givers and quizzers.

Helpers are NPCs that will help participants move through the environment they have implemented a simple adaptive frequently asked questions (FAQ) facility and will attempt to tailor their help to where the participants are in the progression through the quests.

Figure 6-3 Interacting with NPC

Figure 6-4 Starting on a quest in the second prototype

Quizzers are NPCs that have question on themes related to different areas within the C++ programming language. These questions are in a multiple choice format. When interacting with the NPC it will present the question, as seen in figure 6-3, the participants will only have the possibility to attempt each question once. If the participant turns away or chooses not answer, they have the option of coming back and answer another time. A correct answer is rewarded by an item. If a question is answered incorrectly the question is no longer available. The items are all tokens demonstrating knowledge within certain areas of C++ programming.

The C++ environment was also created without the traditional MMORPG elements of fighting, armour and weapons. The aim of the C++ environment is to progress through the quests and be rewarded by gaining knowledge and money. The players finally spend the money on t-shirts and other items at the merchant, and can show these off to the other players.

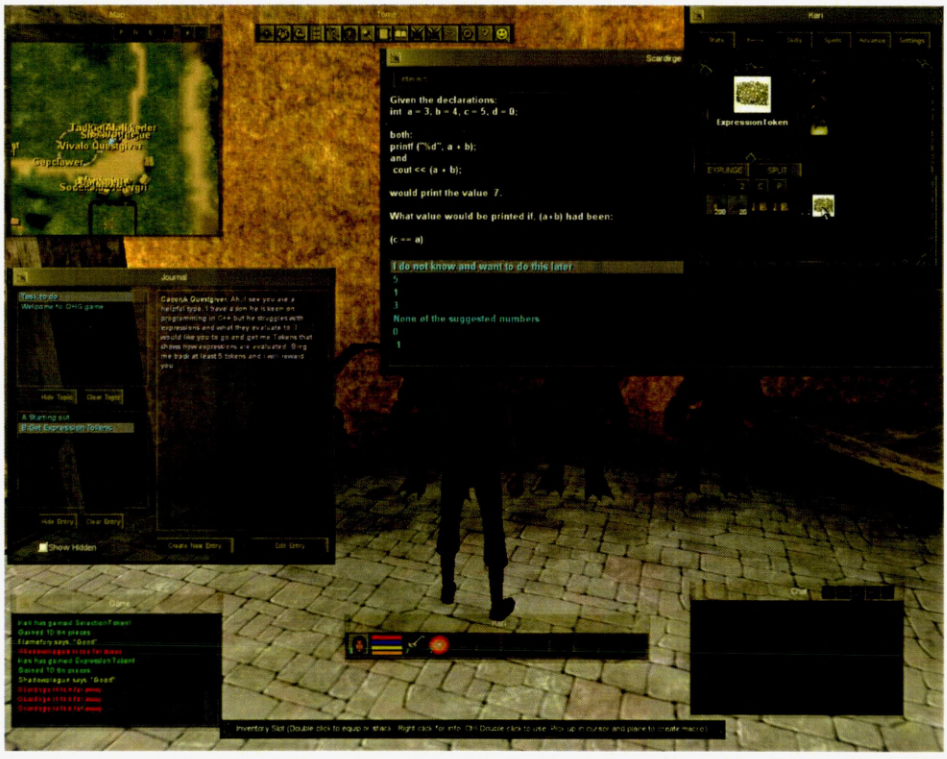

Figure 6-5 Work on a quest, answering questions

Figure 6-6 Progressing on a quest

Figure 6-7 Progressing to the next quest

The different forms of interaction available in the second prototype are the same as for the first, IRC for communication and trading for exchange of items.

6.2.2 Learning content in the C++ environment

The C++ environment is focused around completing different quests. Feedback from the first prototype was that the participants wanted quests that are directly linked to knowledge of programming. The quests for level one are connected to expressions, loops and logic choice (if) in C++. Participants must demonstrate the required knowledge in a topic area by finding NPCs and answering their questions in the same way as the Java version. The difference from the first prototype is that when working on loops the participants will try to find NPCs with questions linked to loops, as there will be NPCs available locally to help them with knowledge on loops, and the replies from the NPCs to an incorrect answer are meaningful and designed to make the participants understand why their answer was wrong. The rewards for answering questions correctly are tokens, which are used to prove knowledge in particular areas. When a required number of these tokens has been collected they can be exchanged for a proof of knowledge in an area, 5 loop tokens are exchanged for a monetary reward and the "key of loops". Collection of all three keys from level one is required to gain access to level two.

In addition to the keys that are collected during the quests, the participants must also collect identifier tokens. These identifier tokens are later used to name variables, parameters, functions, methods and classes.

Level two has two new keys that the participants must acquire: I/O and functions. The key of I/O follows the same pattern as the previous keys, but functions require the

creation of function headings from a description. The same goes for classes in level three. Participants are required to craft a heading for a function that takes a specified set of parameters, e.g. create a function that prints a specified string a specified number of times. The participants is required to first create a String parameter, an integer parameter, and then combine them with a function identifier to create the function heading, then give the created item to the NPC that gave the quest, to complete the task.

Completion of all quests is required to access the final assessment. The final assessment of the environment is to create a rather complex class for storing transmitted messages and receive feedback on it by a tutor. The environment is automatically assessing if the participants have created the correct heading for the final class, the assessment of the complete class implementation is done manually. After the participants had produced a solution to the final assessment it was sent by the environment via e-mail to a tutor for marking, although there was also an option for the participants to send it directly not via the game, if they included their username and sent it from the e-mail registered in the environment.

As in the first prototype, the knowledge that is required to successfully answer the questions, both those of the NPCs and the final assessment could be found within the environment, but could equally well be obtained by any other source, text book, internet, fellow participants online or offline.

6.3 Trials

6.3.1 Trials in Scotland

A group of about 45 students in the first year computer games development course doing a module on C++ programming were offered the possibility to participate in the test of the environment. The environment was introduced to the participants in a standard 2 hour tutorial. The participants were given a 10 minutes introduction to the environment and how to navigate through it. The participants were also given a pre-questionnaire that took between 1 and 5 minutes to fill in. For the rest of the two hour slot the participants were allowed to try out the environment. Both the lecturer of the C++ module and the developer of the environment where present to answer any questions the participants had.

A total of 39 participants showed up for the tutorial and filled in the pre-questionnaire, all of the participants completed the tutorial, and most seemed to enjoy themselves. From observing the participants we noted that not all of them utilised the environment as planned, many seemed very familiar with MMORPG style games and did their best to break it. One participant managed to make his avatar fly, no one has managed that before or since. The participants using the environment in alternative ways did not influence the other participant's progression.

At the completion of the module, some weeks after the initial session all the participants were e-mailed a questionnaire and kindly asked to answer it, several reminders later only a total of 9 participants has handed in the questionnaire.

6.3.2 Trials in Norway

In Norway a group of about 60 students was offered the possibility to test out the environment. The students was a mix of software, electrical and mechanical engineering students all doing a first year module in C++ programming. The test was introduced to the participants in the start of a lecture. As with the Scottish participants the Norwegians were given a 10 minutes introduction to the environment and how to navigate, and the participants were given a pre-questionnaire that took between 1 and 5 minutes to fill in. The rest of the lecture went as normal and there was no way for the participants to test the environment at once. A total of 26 participants participated and filled in the pre-questionnaire, and then tested the environment independently, the majority having downloaded it for home use.

At the completion of the module, some weeks after the initial session all the participants were kindly asked to answer a post-questionnaire, but disappointingly only a total of 2 participants have handed in the questionnaire.

6.4 Results

The questionnaire used for the participants in Scotland and Norway was the same, except the Norwegian participants was given a Norwegian translated version. The results for the pre questionnaire were:

	Scotland		Norway	
	Average	Std dev	Average	Std dev
How would you rate your knowledge in programming so far	3,1	0,7	2,3	0,8
How much do you enjoy programming	4,0	0,6	3,0	0,8
Have you any previous experience with computer games	4,3	1,1	3,8	1,0
How much do you enjoy playing computer games	4,8	0,4	2,5	1,6
Have you any previous experience with MMORPG	3,5	1,4	1,6	0,8
How much experience do you have with games designed for learning	2,4	0,9	2,3	0,7

Table 6-1 Results from the pre questionnaire C++

In summary, the results show us: Scottish participants rank their knowledge on C++ as average (figure 6-8), they enjoy programming (figure 6-9), enjoy computer games even more (figure 6-10) and have a limited experience with computer games designed for learning. Norwegian participants (blue) rate their knowledge on programming below average, they do not enjoy programming particularly, though they have experience with computer games they do not enjoy them as much as their Scottish colleagues (in red), in particular their experience with MMORPGs is low (figure 6-11).

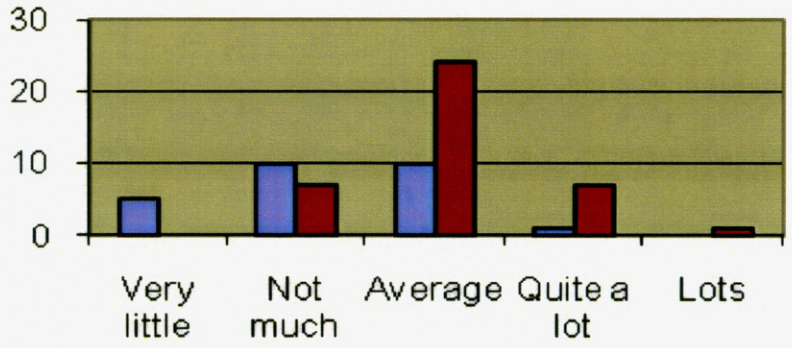

Figure 6-8 How would you rate your knowledge in programming so far

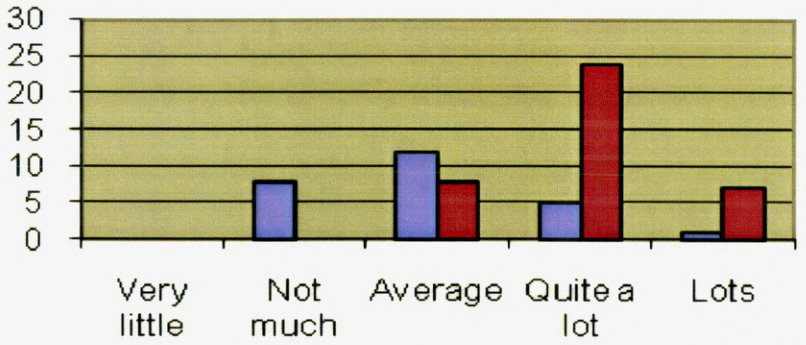

Figure 6-9 How much do you enjoy programming

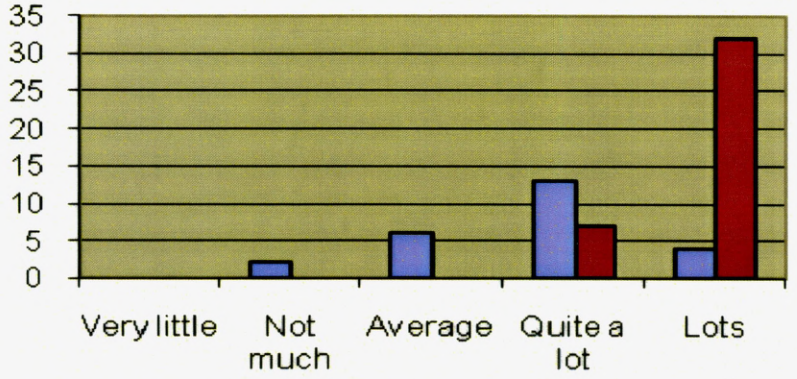

Figure 6-10 How much do you enjoy playing computer games?

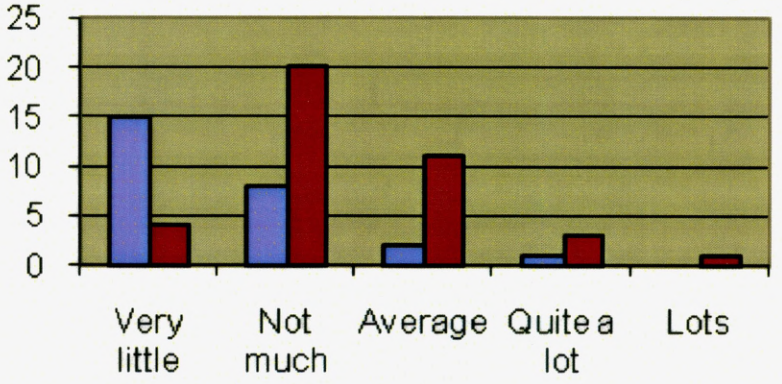

Figure 6-11 Previous experience with MMORPG.

The post questionnaire was only received from 11 participants in Scotland and 2 participants in Norway. The questions and results of the post questionnaire for all 13 students were this:

	Scotland		Norway	
	Average	Std dev	Average	Std dev
Do you feel playing the game improved your knowledge of C++?	2,4	0,9	2,5	0,7
Did the game give you any benefit compared to traditional lecture/lab	2,3	1,0	3,0	0
How much did you enjoy playing the game	2,9	1,2	4,0	0
How much did other students help you during the game	2,2	1,3	1,0	0
Did you have any difficulty navigating the game	3,1	1,5		
How important was the introduction by the lecturer before playing the game	3.6	1.6		
Having played the game how useful do you think games like this are for learning	3,8	2,1	4,0	0

Table 6-2 Results from the post questionnaire C++

The students were also asked how much time they spent learning the environment before they could use it. The results for the Scottish participants are shown below in Figure6-12.

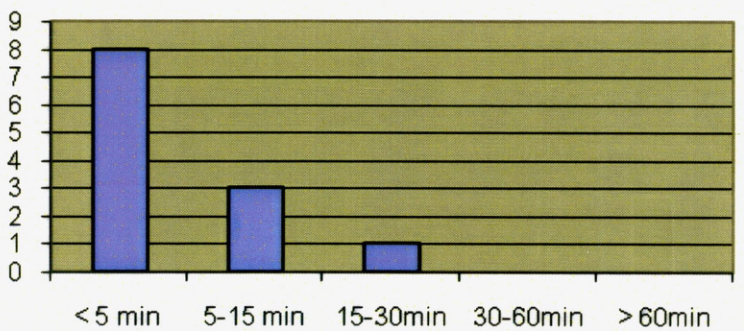

Figure 6-12 Time spent learning the environment

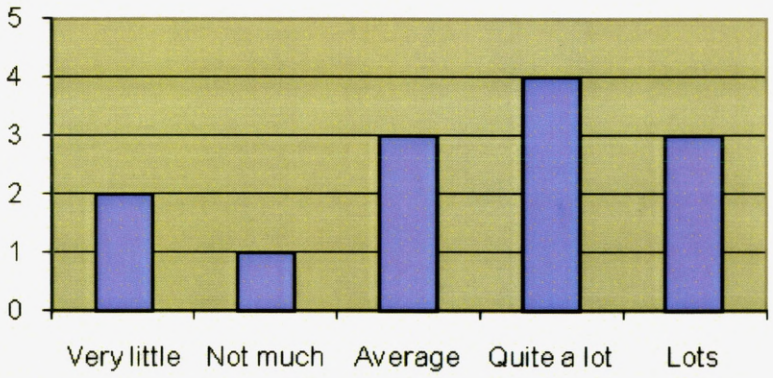

Figure 6-13 Enjoyment in using the game

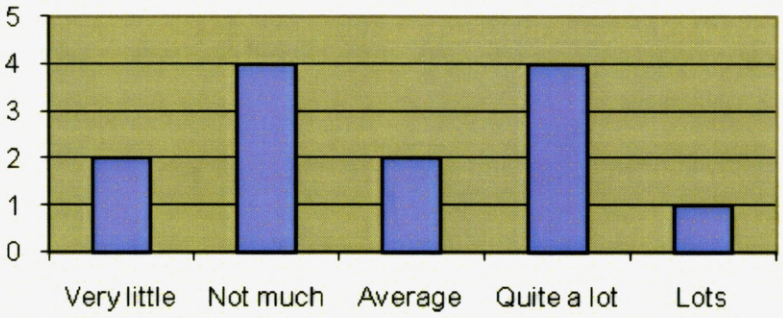

Figure 6-14 Benefit compared to traditional lab

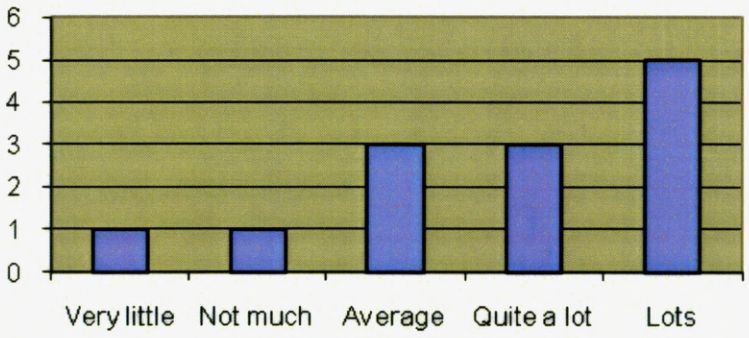

Figure 6-15 How useful are such games for learning

The participants were requested to put their chosen login name on the questionnaires in an attempt to track the participants, only 7 participants supplied this information, below we go through these 7 participants in more detail.

The one participant that marked 15-30 min as time needed to learn the environment before playing have "not much" experience with MMORPG. Another participants needed less than 5 min before playing and had "Very little" previous experience with MMORPG's

All of these 7 participants enjoy playing games a lot, on the question on enjoyment of this game 3 did not enjoy it much and 3 enjoyed it quite a lot. Five of the participants think that games like this for learning is a good idea, answered above average, the last two marked not much and very little, one of these participants is the same that took 15-30 minutes to learn the environment and had little previous experience with MMORPG's. The ones that took longest to start is one of the two participants that do not have belief in this as a learning tool.

The questionnaires from the C++ environment did only have one comment,: *"It felt good that I was learning from the game, and that it was actually helping me understand C++ a little better"*

The system do also gathered information on when the participants logged in to the environment. The usage statistics show that, with a small number of exceptions, the Scottish participants never used the environment again after the initial two hour session. Of the Norwegian participants there were about 10 that actually used the environment and they all logged in over a period of two to three weeks on numerous occasions.

6.5 Initial conclusions from the study

Most of the participants that showed up for the tutorial and trial seemed to enjoy themselves. The comments were generally positive and quite a few appeared to demonstrate a better understanding of C++ as a result of the study. Again a few participants just played with the environment completely ignoring the learning part, these participants were generally very familiar with MMORPG style games and made some negative comments about the old fashioned graphical look of the environment, and otherwise generally just wandered around, quickly getting bored. These participants using the environment in alternative ways, and did not influence the other participants progress. After a while, most of these focused on the learning content.

The lack of continued play by the participants is disappointing, as this suggests they did not find the prototype engaging enough to want to spend more time on it. None of the participants completed the learning content, though a few were quite close, so that should not be a factor. However, there was evidence from the feedback from students, and form some of the activity when the students were taking part in the study, that suggested students felt there wasn't enough game-play to warrant returning to the game. Additionally, the students did not echo the comments from the previous study criticising the relationship of the learning material to the game and finding it detracting from their enjoyment. This suggests that embedding offers a better approach to integrating learning materials in to game-play, but there needs to be sufficient game-play richness and activities within the game to achieve reuse and socialisation..

7 Study three – Extrinsic bespoke: Learning content is modelled as quests and no pure game elements are added

The prototype described in this chapter is a game developed for a course in analogue electronics, and the topic is the design of a stable power supply. This task can be solved in a number of different ways, with certain constraints, giving the students a certain amount of freedom. The learning content is modelled not to facilitate trial-and-error approach, while maintaining a way for the students to explore.

The prototype is created specifically for the learning content in contrast to the previous two studies described in chapters 5 and 6 this prototype does not start out with a game that gets the learning content added on, this game or environment is build for purpose. One main factor in deciding to build this prototype was an aim of completeness in the studies, layering information on top in prototype one (chapter 5) embedding into a game (chapter 6) and a game/environment build for purpose (this one). The focus of the testing is to determine how a game build for purpose compares to the other prototypes that are based on games content, the study was also used to help determine whether removing all explicit game playing activities not directly linked to the learning material still makes it possible to create a game that can be engaging for the participants. The participants are asked to fill in a similar form to what is used for the previous studies.

The study in this chapter with results have previously been presented twice first as a preliminary version as [10] "Games-based environment for e-learning in analogue

electronics," at ICL in 2008 Villach, Austria, then in full as [2] "Computer-based Role Playing Game Environment for analogue electronics,", in International Journal of Online Engineering 2009, vol 5.

7.1 Games based environment for analogue electronics

The participants in this study are second year bachelor students, studying of a degree in electrical engineering, at Buskerud University College, Norway. The learning content was supplied by the module tutor in the module.

7.1.1 Learning content in the environment

A large part of the module that runs this prototype as part of the activities is devoted to give the students a deeper understanding of the relations between voltage and current: Ohm's law. The module tutor has observed that students seem to have difficulty progressing from the very simple uses of Ohm's law, to utilise it on more complex systems. The student face challenges in understanding, for instance, how a voltage drop over a resistor affects the voltage potential in a circuit. The purpose of the prototype is to make students work towards a goal, the route to this goal is made up of several steps similar to the tasks they normally would undertake in a class setting, solving the same overall task. One of the main requirements set by the module tutor for the prototype is the possibility of accepting several correct solutions, which is normally the case in the real world. In a traditional class setting, the students are presented with a single solution, and may be told that other solutions also exist but they have a limited ability to explore these solutions in a lab setting.

7.2 Content

7.2.1 Design of the environment

Below are shown some screenshots from the prototype. Picture 7-1 show the scene at the beach where the participants first lands. Picture 7-2 shows a participants being presented with the first quest, notice the assignment text in the lower left window on the screen. Picture 7-3 shows the participants acquiring components from the shop. These components are later used by the participants in the construction of circuits. The other windows shown in the pictures are starting from top right and going clockwise: map, crafting, inventory, shop, chat, macros and messages from the system. Figure 7-4 shows the journal, specifying the current task, and their work window (Inventory). In addition the chat window and messages from the system window can been seen

Figure 7-1 Starting out on the beach

Figure 7-2 Getting the first quest

Figure 7-3 In the shop

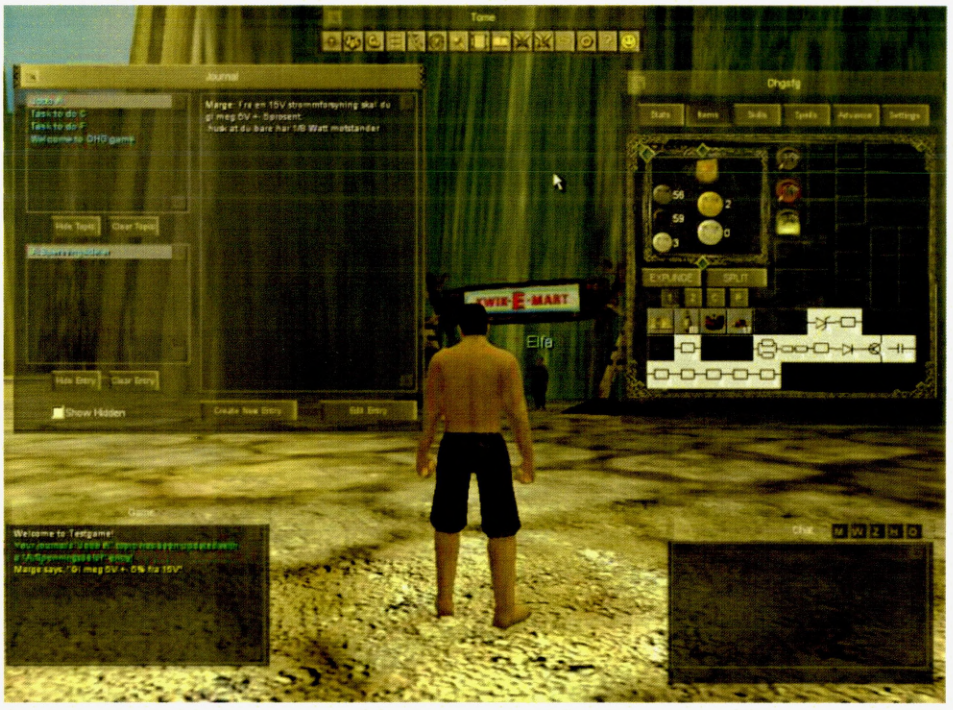

Figure 7-4 Working on a assignment

In the prototype, the participants have several ways of getting help. The primary source of help will be given by the NPC's in the environment. As the participants are given a task, they are given a small amount of information apart from a problem description, this not to overload the participants with help they do not require. Upon visiting the same quest giver again that will either receive a small piece of information and/or a hint of where to find more help on progressing on the current quest. This more help may be inside the game in the form of a wise man or looking up some web address, or simply a direct pointer to a chapter in the textbook used in the module.

The environment also contains a system for communicating with other participants. It is the author's hope that with enough participants playing the game at the same time this will be the main source of help. To facilitate the use of in game communication, there are two main ways for students to interact with other participants in the environment, these are the standard facilities used in all MMORPG type

environments, chat and trading. The chat system contains several channels dealing with: people close by, people in the same area, all people, a help channel, and an off topic channel for all communication not directly linked to the environment and learning. The chat window is seen in the screenshots as the window on lower right part of the screen in Picture 7-1,7-2,7-3 and 7-4. Trading is an option for participants to buy and sell different items. It must be noted that most constructed and gained items on quests are not allowed to be bought and sold, this is a limitation we have set and the reason for this restrictive practice is that it is the possession of these items that is used to track the progress of the students through the environment. All basic components that are bought by the students from the in game shops are freely tradable and a group of participants can cooperate on the purchases and thereby progress quicker than non cooperating participants.

7.2.2 Learning content

The starting point of the story set in the prototype is a situation where: "the students[participants] have access to a bicycle generator, and several electronics shops where they can get different components. The task is to build an advanced charger for their mobile phones, utilising the bicycle generator as the power source for that charger. To complete the task the students [participants] have to start out by buying discrete components to build the different parts of the charger." [10] There are a number of different steps which must be fulfilled to assemble a complete charger. Several of these are dependent on each other, while others are independent, based on the discrete components, thus allowing the participants the freedom to explore the learning material on their own.

Participants assemble the circuit in the different steps, each modelled as quests inside the prototype. Each of these quests contains elements that make it possible for the participants to select both wrong and correct solutions, as is the case in the real world. For instance: *"when assembling a voltage divider, choosing resistor values that are too small will result in a circuit burning up, while choosing values that are too large will result in excessive output impedance, and a useless circuit. Within these limits, there are several working circuits, which the students should be able to calculate."* [9] The quests are constructed in such a way as to allow a sufficient number of different resistor values, as to render the simple trial-and-error strategy impractical and the students are placed in the position of having to utilise Ohm's Law to achieve a successful outcome. Participants will face three different outcomes for the voltage divider: The circuit burns up; the circuit doesn't work (due to high output impedance, or wrong resistor values); or the circuit works correctly as desired. The participants can attempt to solve the problem as many times as they wish, but as noted above the range of outcomes will exceed most participants' willingness to just guess the solution, and a successful solution will probably represent appropriate application of Ohm's Law.

The design of the prototype as with the others is created to be easily extendible, and the authoring of the learning material can in future be mostly undertaken by the tutors in analogue electronics themselves, after being given just a short introduction. However, more complex tasks may require greater complexity and they will typically require some assistance from a programmer.

7.2.3 Structure of the content

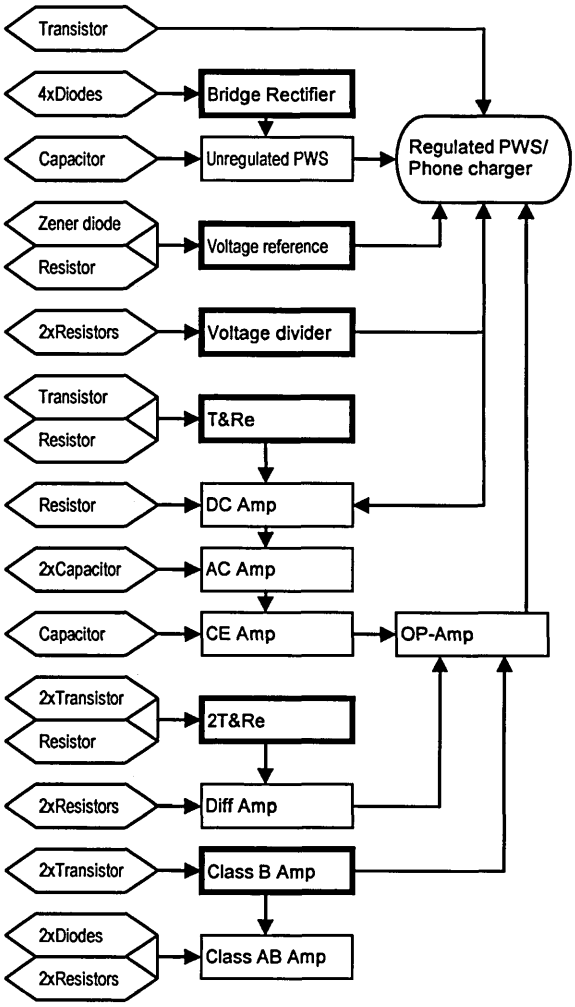

Figure 7-5 Structure of the content in the third prototype

As noted before the prototype is made up of steps, modelled as quests. These quests consist of simple electric circuits that the participants will assemble to complete the quests. Participants build these circuits on their own, using the components can buy in the in shops, inside the virtual environment. Some quests are made up of several intermediate steps. In order to construct more complex structures, some of the later steps are dependent on the fulfilment of preceding steps, while others are completely independent. There is several ways to progress through the game, See Figure 7-5.

The participants overall goal are to build charger for their mobile telephone. An overview of the charger which is simply a voltage regulator is shows in fig 7-6 as a block diagram.

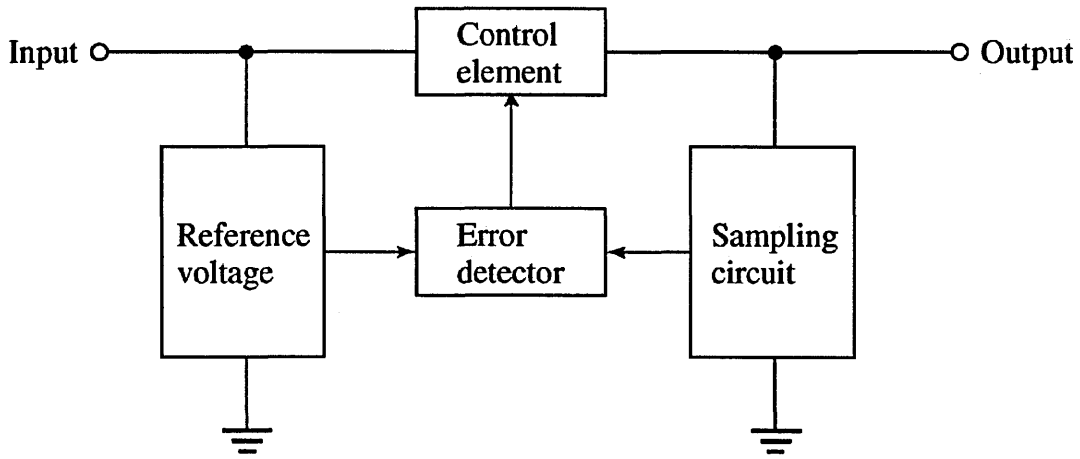

Figure 7-6 Block diagram, voltage controller

In figure 7-6 the control element is simply a large transistor, while the voltage reference is a series connection of a resistor and a zener diode. The sampling circuit has an equally simple construction, with two series-connected resistors. The error detector consists of three different amplifiers: a differential amplifier, a small signal amplifier and a class B power amplifier. The quests are constructed with an aim that the participants should recognise the quests as part of the block diagram. A diagram similar to this can also be found in their textbook.

Six of the quests can be completed using only discrete components, all of which are available from the start form the shop. This means that a participant can start on any of the six quests at the start of the game, and they may also be abandoned and later restarted in any order. These starting points are shown with bold frames in fig.7-5.

The quest to build the error detector (OpAmp) can only be built after the three amplifiers quests have been completed. The construction of the last step (the constant voltage charger) can naturally only be started after all the other steps have been completed

"This scheme is thought to give the students[participants] a thorough walk-through of the design of a stabilized power supply, including all the important calculations and considerations."[10]

7.2.4 Game-play and content in the analogue prototype

The story presented for the participants as they enter the environment is that they are on an island. The first NPC (person) they meet gives each of the participants a mobile phone – with an empty battery. They are also informed that there is an old bicycle with a generator that can be used to charge the battery, this then established the overall goal for the participants. They are then informed that in order to achieve this goal they first need to build a voltage regulator to put between the generator and the mobile phone, and so the overall goal is established as an analogue electronics subject specific goal. The participants are also informed that all the components needed are available through a number of shops on the island, and told that the task for the participants is to use their skills and knowledge to assemble these components into something useful – such as a phone charger. If the participants lack some part of the knowledge or skill they need to acquire this, through the material embedded into the environment, getting help from fellow participants or by going to sources outside the environment. The assembly of this phone charger (which is actually no more than a voltage regulator) is the main goal of the game.

In order to get access to the components, the participants are given a small amount of money at the start of the game. This can be used to buy components from the shops. For the game to be more realistic the components are priced proportionally to what is expected in a normal (real-life) shop, the participants are also informed that the money is not limitless and is therefore also helping to discourage the trial-and-error approach.

Fig.7-6 shows the outline of how the voltage regulator should be assembled. The individual parts of the voltage controller can be assembled in any order, but all sub-parts have to be completed before the final assembly of the voltage controller.

7.2.4.1 Quest Voltage divider

The voltage divider is built from two series connected resistors. The participants are told to make a voltage divider that gives out half of the input voltage. The output resistance should also be within certain limits. This, in combination with the power ratings of the resistors available, gives the constraints on how to make this voltage divider. The testing the voltage divider would return burnt plastic if the resistance is too low.

7.2.4.2 Quest Voltage reference

The voltage reference is assembled from two different components: A resistor and a zener diode in a series connection. There are three possible outcomes when this assembly are brought in for testing: Burnt plastic, not working or, the desired, a working circuit. A too low value on the resistor would lead to burnt plastic, while an either too high value of the resistor or a wrong value on the zener diode would lead to a non-working circuit. In order to find the correct value of the resistor, the power

rating of the resistor, the maximum input voltage, the power rating of the zener diode, as well as the knee current of the zener diode all has to be taken into account.

In order to find the correct value of the zener diode (there are three different voltage levels to choose from), the relation between the voltage reference and the sampling circuit has to be understood: When the correct output voltage of the voltage regulator is achieved, the output of these two sub-circuits should have the same voltage.

7.2.4.3 Quest Differential amplifier

The next natural step is to assemble the differential amplifier, although any of the three next steps can be done in any order. The differential amplifier is assembled in two steps. First two identical transistors are combined with a resistor. This resistor will be the common emitter resistor for the two transistors. This assembly gives a new unit, which in turn can be combined with two identical resistors that gives the two collector resistors.

In the first step, the one resistor should have a value between 1kohm and 6.8kohm. If lower than this value, the tester will return burnt plastic, if higher a non-working circuit will be the result. In the next step, any values lower than 10kohm will return burnt plastic, while values larger than 68kohm gives a non-working device. Anything between these limits returns OK.

7.2.4.4 Quest Voltage amplifier

The voltage amplifier is based on the voltage divider made earlier, in combination with a transistor of any kind, and two resistors. While this is done in two steps, the actual testing is performed on the final assembly. In order to differentiate between the

collector resistor and the emitter resistor, it is stated and assumed that the emitter resistor is added first of the two resistors. Any resistor values between 1kohm and 10kohm are considered OK as long as the emitter resistor has a lower value than the collector resistor. Any resistor having a value below 1kohm gives burnt plastic. Anything else gives just a thing that does not work. [10]

This circuit is further enhanced into a normal common collector amplifier by adding capacitors within certain bounds. Choosing the wrong capacitors cannot lead to burnt plastic, but the not working circuit.

7.2.4.5 Quest Power amplifier

The power amplifier is supposed to be a normal class-B amplifier. This is simply made up of two complementary transistors and two identical resistors. The resistors should not be too small, nor should the transistors have two low current limits. This would lead to burnt plastic. Anything else having two complementary transistors and two identical resistors, gives a working circuit.
These three circuits will be combined to form an operational amplifier, and as the preceding steps are completed successfully, the assembly is assumed to be OK. This represents the error detector in fig. 7-6.

As a small sidestep, the students are encouraged to build a class-AB amplifier, and present this to "The Lone Guy somewhere in the hills around here". If done correct, the prize is a very special t-shirt for the avatar and a piece of silver.

7.2.4.6 Quest Rectifier

In addition to the circuits above, a rectifier circuit is needed. This also have a filter capacitor of a certain size. The rectifier is a normal bridge rectifier, and the students are informed that it should be able to handle a relative large current. This means that the only circuit allowable here is four diodes of the highest rating available for the students. This bridge must be combined with a capacitor with value no lower than the two highest capacitances available

7.2.4.7 Quest the final assembly

The final assembly according to fig.7-6 can be made, as all the elements are completed, in addition to the control element transistor. It is again assumed that as long as all the preceding steps are OK, so will the final assembly be. After completing the phone charger the player can find the bicycle and start charging the phone, and gain the ultimate goal in the prototype a charged phone.

7.3 Trials

The participants in this study are second year bachelor students, studying of a degree in electrical engineering, at Buskerud University College, Norway. The questionnaire used for the analogue electronic students was the same as was used for the previous trials on Java and C++. The group of participants are Norwegian and the questionnaire is a Norwegian translation of the original questionnaire

Question	
1	Hvor mye kan du om strømforsyninger i analog elektronikk? How would you rate your knowledge in analogue electronics?
2	Hvor mye liker du å jobbe med analog elektronikk How much do you enjoy working with analogue electronics?

3	Har du tidligere spilt dataspill Have you any previous experience with computer games
4	Hvor mye liker du å spille dataspill How much do you enjoy playing computer games
5	Har du tidligere spilt MORPG (Multiplayer online Role playing Games) Have you any previous experience with MMORPG
6	Hvor mye erfaring har du med spill laget for lærling How much experience do you have with games designed for learning
7	Hvor mye likte du de spillene laget for læring som du har spilt How much did you enjoy games designed for learning

Table 7-1 Pre questions for the analogue electronics experiment

7.4 Results

. The pre questionnaire was received from 28 participants. The results for the pre questionnaire were:

	Very little	*Not much*	*Average*	*Quite a lot*	*Lots*
Question 1	0	9	12	7	0
Question 2	0	5	14	9	0
Question 3	0	6	6	8	8
Question 4	0	5	10	6	7
Question 5	16	2	4	3	3
Question 6	10	10	6	1	0
Question 7	5	7	9	4	0

Table 7-2 Results for pre questions for the analogue electronics study

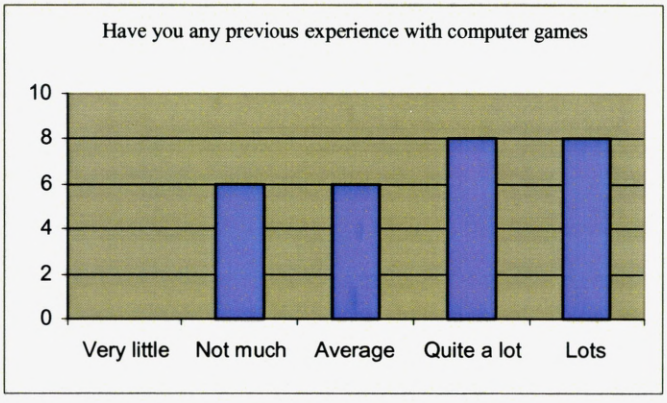

Figure 7-7 Have you any previous experience with computer games

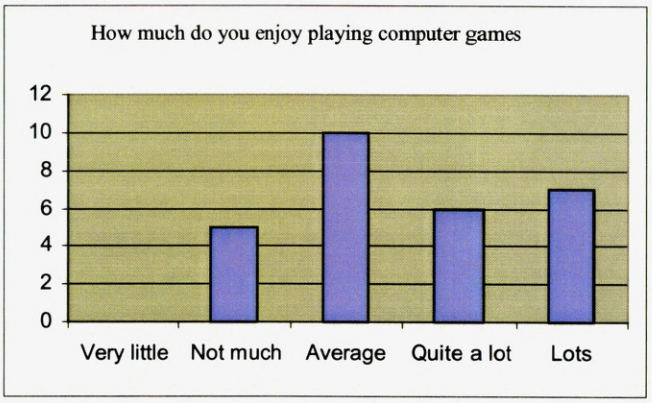

Figure 7-8 How much do you enjoy playing computer games

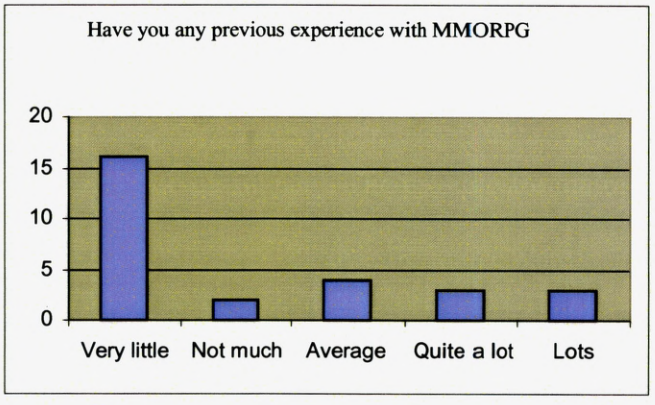

Figure 7-9 Have you any previous experience with MMORPG

The post questionnaire was not received from any participants. The logged information from student logins shows that only a couple of participants logged into the system after the initial 2 hours session. The oral feedback received from participants, when asked about why the system was not used more, the responses are:

- *"It is more efficient to do traditional tutorial/lab."*
- *"To close to the exam, I need to study."*
- *"Don't like computer games"*
- *"Don't like games."*

7.5 Initial conclusions from the study

The lack of interest from the students in this study was evident from the initial introduction to the environment. The few comments made by the participants were positive, but most showed little interest. When questioned about the lack of interest the feedback from the participants was that the game was made available too close to the exam in the module and they elected to focus on traditional preparation to the exam. In addition quite a few of the potential participant plainly stated that they did not play or even like to play computer games.

The findings in this study does not invalidate the game produced but the nature of the game, created with specific learning material and designed especially for this learning material the reuse of the game is very limited. And there has not been an opportunity to rerun the study at a more convenient time for the students.

8 Study four – Intrinsic bespoke: Short multiuser game with quests used in as part of blended learning

The study described in this chapter is also used to determine the viability of using a computer game specifically designed to incorporate abstract learning materials as part of a blended learning environment. The participants first use the game before they are involved in a workshop focusing on the topics identified by their lecturer. The learning content in the game is designed as an abstraction of the topics the participants are working with in the workshop. The learning content is routing in computer networks. The lecturer of the module had previously identified routing as an area where the students would benefit from increased motivation, if they could be enticed to engage more with the subject matter.

The learning environment is created with no game elements other than those that are necessary to solve the quests given to the participants during the game. The game can be run both as single and multi-player. The study was carried out as a competition for the participants during this experiment, and ran as a multi-player game. This prototype is the fourth and final type of games created as part of the study investigating the success of placing learning material in gaming environments, and follows on from previous studies in chapters 5 through 7. As well as considering the value of the prototype in supporting a blended learning exercise, the study was used to help determine whether removing all explicit game playing activities not directly linked to the learning material still makes it possible to create a game that can be engaging for the participants. The participants are asked to fill in a similar form to

what is used for the previous studies, whether they feel playing the game improves their knowledge, if they enjoy this form of learning, and if they find it useful.

The study in this chapter with results will be presented as [11] "Games-based environment for e-learning in analogue electronics," at ICL in 2009 Villach, Austria

8.1 Games based environment for routing in networks

Routing in a packet switching network, such as the Internet, is the process of determining the transmission path of a data packet from some source to some destination. In general we separate between routers, computers that forwards packets based on routing decisions, and hosts, machines that reside at 'the edge' of a networks, either as a source of or destination for a packet.

Hosts and routers are connected by local networks called lines. There are various local network standards, with different properties. Some of these properties are of interest in a routing context, such as bandwidth, delay and load. These can be combined in a routing metric, used to order lines with respect to desirability in terms of transmission. By associating a metric to each line we can employ a routing algorithm to determine the optimal path between any source and destination.

There are various kinds of routing algorithms and we distinguish between static algorithms where the routing algorithm is performed only once, and dynamic algorithms where the routing information is updated continuously to adapt to changes in the network topology. The most common routing algorithms are so-called link-state algorithms: Routers exchange information about their neighbours to all other routers in the network. Then each router has knowledge of the complete topology of the

network, and can use this information to compute optimal paths. Routing tables are generated based on this information and subsequently used for forwarding.

The usual theoretical model used to represent a network for routing purposes, is that of a graph, directed or undirected. The hosts and routers are the vertices, the lines are edges, and each edge has the corresponding line's metric as cost. The model of a graph can also be applied, as it is in our game, to a maze: intersections are vertices and corridors are (undirected) edges.

An edge cost that could function as an intuitive routing metric is the length of the corridors - the longer the corridor, the longer time the player has to run. This cost is explicitly introduced to the players as signposts at intersections. Routing information is gathered by traversing the maze, while forwarding is modelled by choosing a corridor when arriving at an intersection.

The prototype described in this chapter is a game developed for a module in networking, and the topic is routing of information in a network. This prototype is tested by participants from a group of second year computer engineering students at Buskerud University College.

One of the aims for the module on computer networks is that the student shall know how today's computer networks are constructed, and be familiar with today's network technology, and how they work. The prototype created for this study is created to create extra/inject engagement into what is perceived as an uninteresting subject area by the participants.

8.2 Content

The game is created to give the participants a feeling of some of the challenges for routing and what possible algorithms can be used to deliver information through a network. The game is created as a labyrinth where the avatars controlled by the participants have to move. Nodes in the network is modelled as junctions, all junctions have signposts with information about the distance to immediate neighbours. Hosts are modelled as open areas where a NPC is placer for the participants to communicate with, deliver packages and receive new packages and instructions for new deliveries.

A map of the labyrinth the participants was asked to navigate is included as figures 8-1, junctions are numbered and hosts are marked with letters.

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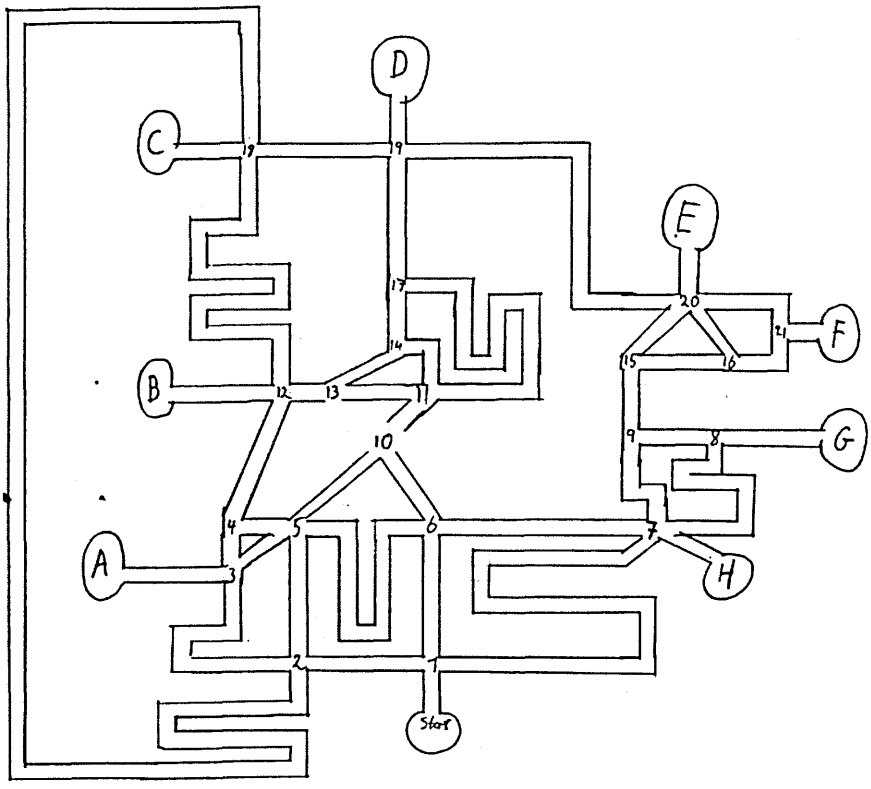

Figure 8-1 Map showing the labyrinth in the networking game

8.2.1 Game-play

The game-play in the prototype is simple, and combines routing and forwarding. Participants start out in an area, marked *start* on the map. In this area there is a Non Player Character (NPC) that gives them quests to perform. These quests all consist of delivering a package (representing a 'data packet') to another NPC (host) somewhere. Participants are neither told where the destination is located nor about the layout of the maze. The aim is to run to the NPCs location (simulating transmission of the data packet), and deliver the package to them, the NPC at this location will then hand the participant another package for a second destination and so on. All quests are made up of five such steps. When the final NPC of a quest gets their package the reward is one piece of gold, and an instruction to go back to the start for another quest.

At the beginning of the game, the player will receive their first item, but must, since they have no knowledge of the maze layout, search blindly for the destination.

8.2.2 The prototype

The game is built on the same MMORPG kit as all the other prototypes, but several features are disabled. The disabled features are map, tracking and other navigational features

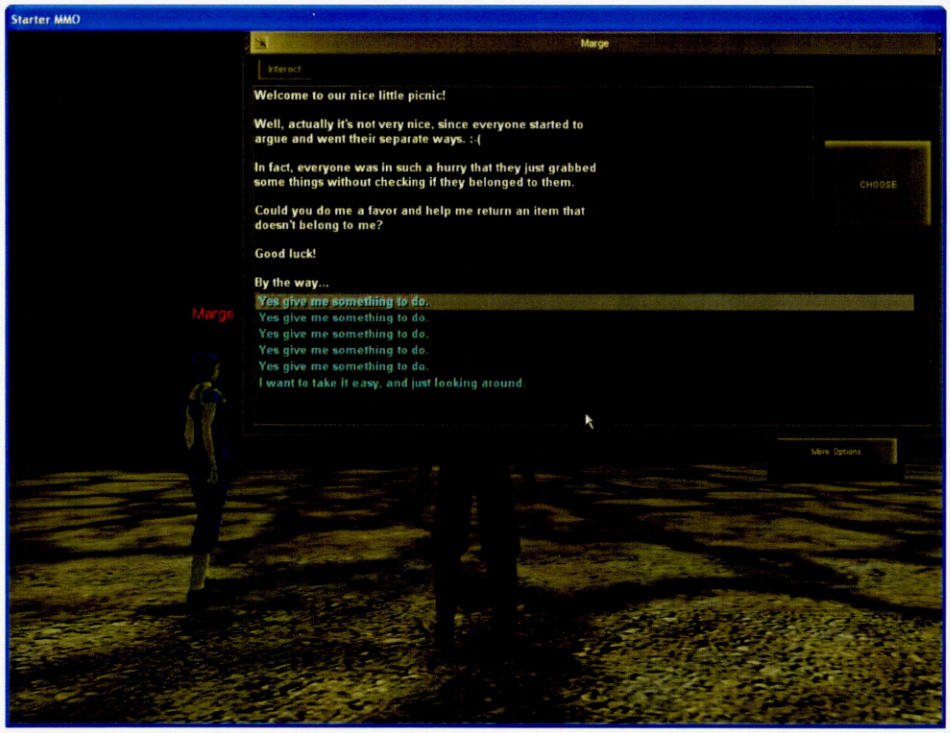

Figure 8-2 Starting out on a network quest

Picture 8-2 show the scene at the beginning where a participant can select any one of a number of new quests. Previously started quests will automatically be removed from the list. A participant is also permitted to start just one quest at a time.

Figure 8-3 Got the first item of a network quest

In picture 8-3 we can see that the participant has received the first item to deliver. The participant is given no other information than this is a doughnut and that it is required to keep it in your inventory. It is also marked as "soul bound" this mean that it may not be given to any other participants. Participants is also given the information in the lower left window that the NPC "Homer" is the intended recipient of the item, but no other information. As can been seen from the map the only way out is north, though the participants don't even know that this is north.

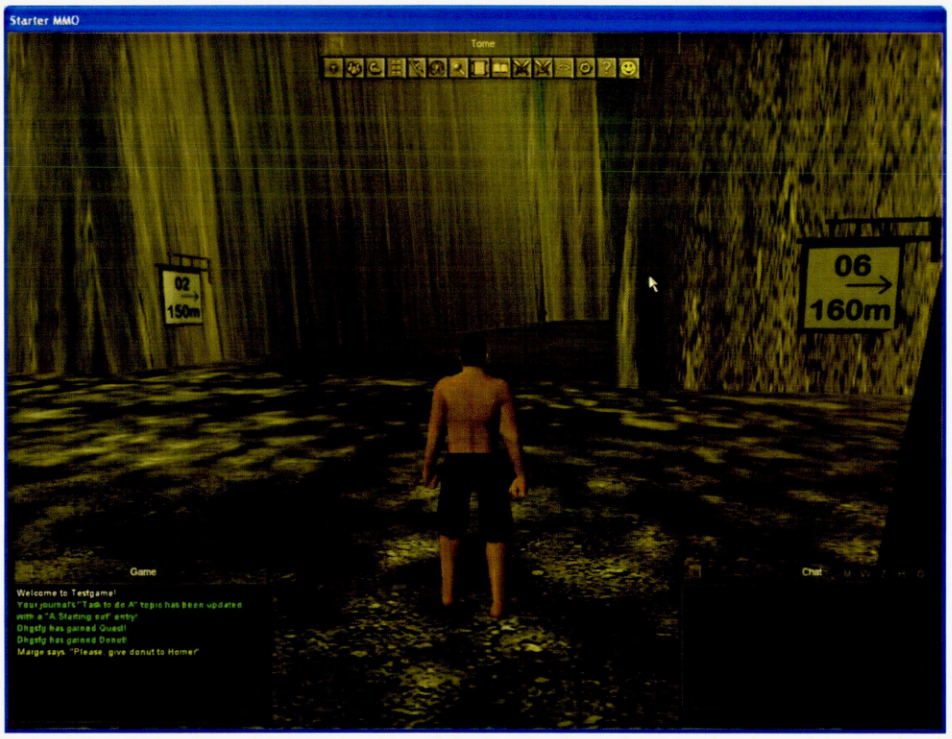

Figure 8-4 First junction in the networking prototype

Figure 8-5 Avatar view in the networking prototype

Picture 8-4 shows the view that meets the participant when entering the first junction.

Three signposts (only two shown on picture) with information about what junction

can be found in that direction and how far it is. The distances are roughly correct if the avatar is a normal human, though it is a human that is able to run quite fast over long distances with no drop in speed. Picture 8-5 shows a different place in the labyrinth. Note that the only information that the participant can use to navigate is the signposts, no other directional information is available.

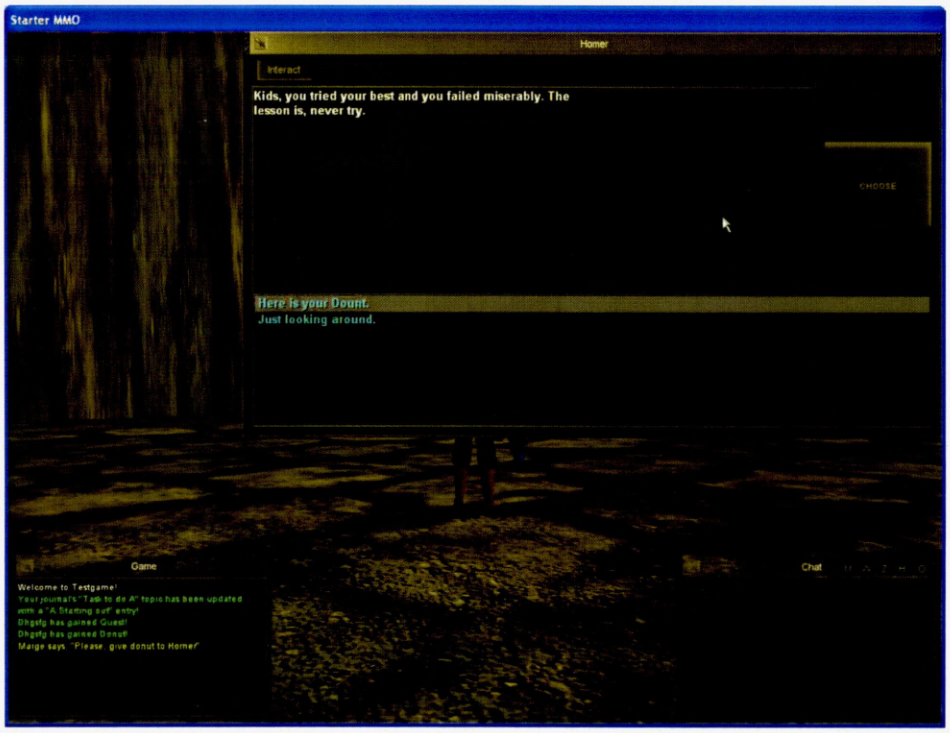

Figure 8-6 Handing over an item in the network prototype

Picture 8-6 shows the exchange that takes place when we have found the NPC that the item is intended for. If the NPC is not the correct one the first line in the dialogue window would be missing.

Figure 8-7 A quest is complete

Picture 8-7 shows a complete quest. The dialogue that has taken place is shown in the "Game" window on the lower left and the automatically generated journal that the participant can use at any time during the quest is shown on the right. The obscured window below the journal is the chat window that can be used by the participants at any time trough the game to communicate with the other participants currently in the game.

8.3 Trials

The trial was run in an ordinary classroom where participants used a mix of standard PCs and their own laptops. The game was preinstalled on the PCs, and in addition the participants were free to download and install the client on their own computers. The lecturer also logged in and used a projector to show his view in large format for all to see. The participants logged in and had about 10 minutes to familiarise themselves

with the controls and options available in the game. Then the lecturer set the scene for the "game" to begin.

The lecturer had previously decided that the "game" would be a competition the winner would be the participants who was able to buy a t-shirt from the shop and put on first. The cost of a t-shirt meant that a participant had to complete a minimum of three quests to acquire the funds necessary.

All participants gather together so they were in view on the main screen and the race was on. First they where guided to a group of NPCs all of them generated as a clone of the start NPC, this gave all the participants an option to start simultaneously.

Though the system was available for the participants after the study, continued use of the game after the initial session were the game was run, was not part of the study and no statistics on reuse was saved.

The participants filled in pre- and post-questionnaires, detailing their familiarity with games, their attitudes before, and their impression after completing the study.

8.4 Results

The questionnaire used for the computer networks participants was much the same as was used for the previous trials. The questionnaire it is slightly simplified as there is no explicit learning content in the prototype. The group of participants are Norwegian and the questionnaire is a Norwegian translation, in addition the pre and post questionnaire is handed out at the beginning as a two sides of the same sheet of paper.

The questionnaire was received from 12 participants. The results for the questionnaire were:

Pre-game questions	
1	Have you any previous experience with computer games
2	How much do you enjoy playing computer games
3	Have you any previous experience with MMORPG (Multiplayer online Role playing Games)
4	How much experience do you have with games designed for learning
5	How much did you enjoy games designed for learning
Post-game questions	
11	How much time did you spend learning the environment before you could play
12	Do you feel playing the game improved your knowledge of Networks?
13	Did the game give you any benefit compared to traditional lecture/lab
14	How much did you enjoy playing the game
15	How much help did the others give you when playing
16	Did you have any difficulty navigating the game (Not the labyrinth)
17	Did you have any difficulty navigating the labyrinth in the game
18	How important was the introduction by the lecturer before playing the game
19	Having played the game how useful do you think games like this are for learning

Table 8-1 Questions used with the networking prototype

	Very little	Not much	Average	Quite a lot	Lots	Average	Std var
Question 1	0	1	2	3	6	4.17	1.03
Question 2	0	0	2	5	5	4.25	0.75
Question 3	4	4	0	2	2	2.50	1.57
Question 4	5	7	0	0	0	1.58	0.51
Question 5	3	3	5	0	0	2.18	0.87
Question 11	1	6	0	0	0	2.00	0.50
Question 12	0	2	7	1	0	2.92	2.92
Question 13	0	2	8	0	0	2.83	0.58
Question 14	0	0	4	5	1	3.67	0.65
Question 15	4	1	5	1	1	2.50	1.31
Question 16	5	5	1	0	0	1.67	0.65
Question 17	0	0	3	4	2	3.83	0.72
Question 18	1	1	2	3	1	3.36	1.12
Question 19	0	0	4	4	1	3.75	0.62

Table 8-2 Results of questions both pre and post networking game

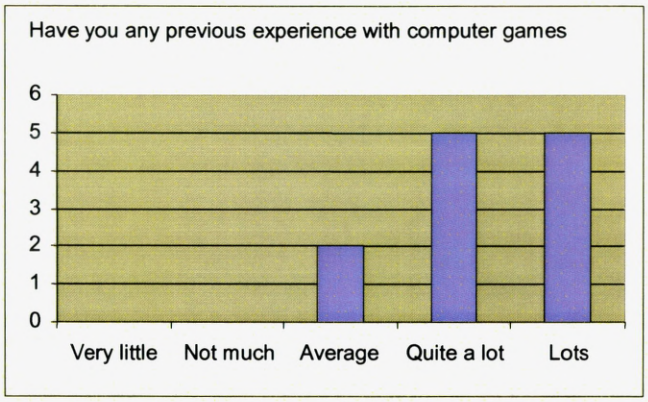

Figure 8-8 Previous experience with computer games

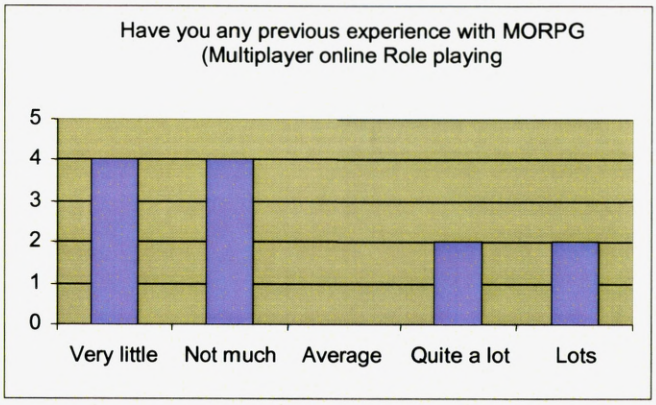

Figure 8-9 previous experience with MMORPG

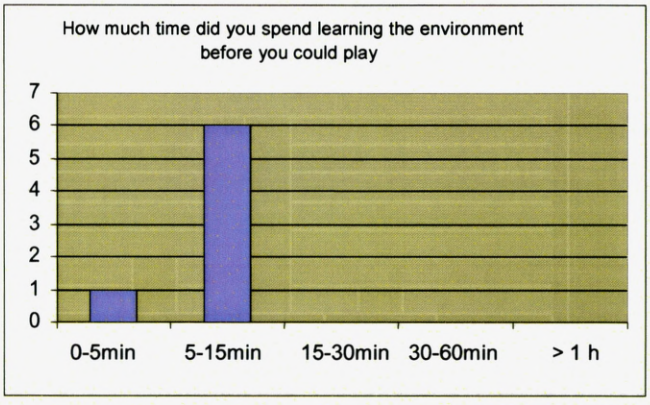

Figure 8-10 Time did you spend learning the environment

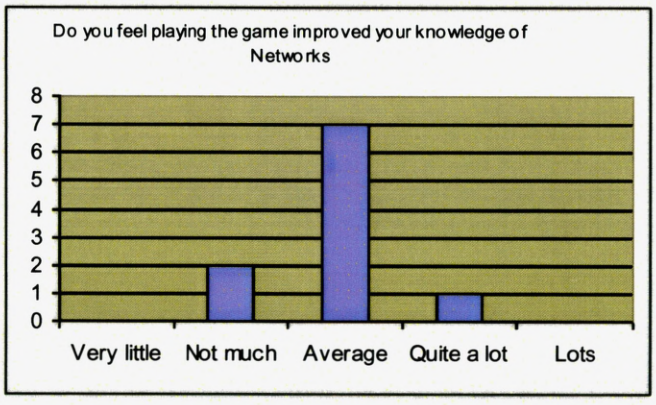

Figure 8-11 Did playing improve your knowledge

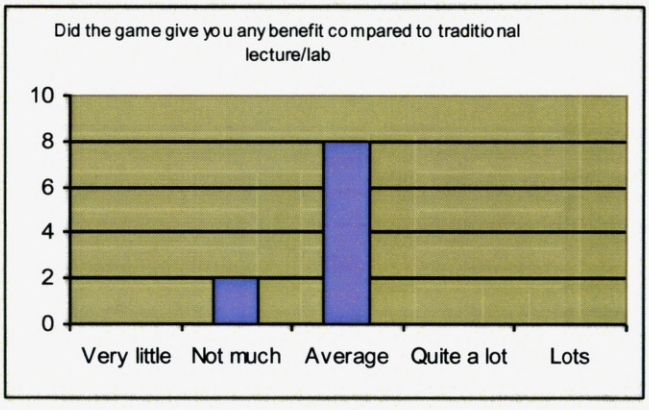

Figure 8-12 Benefit compared to traditional lecture/lab

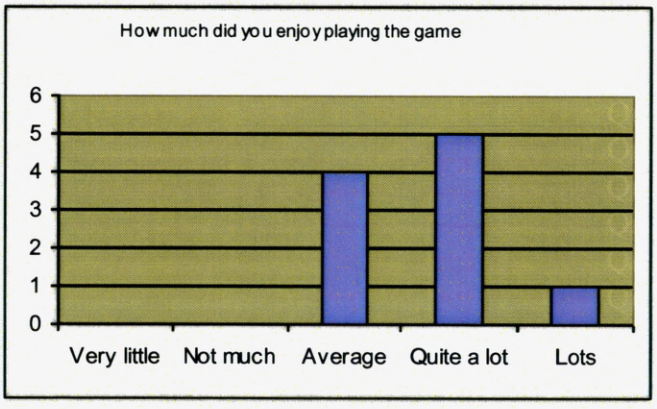

Figure 8-13 Did you enjoy the game

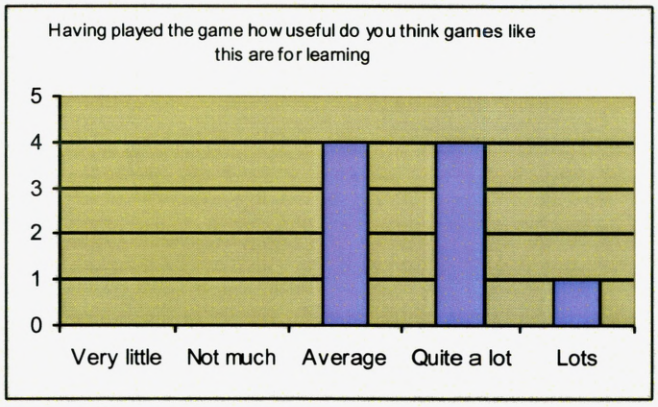

Figure 8-14 How useful are games like this for learning

In addition to the questions the participants were also given the option to comment. Of the few participants who took advantage of making a comment they wrote short statements like: nice idea, fun, more of this. Comments made in Norwegian this is an approximate translation.

8.5 Initial conclusions from the study

This study utilised the game as an introduction to a topic identified by the lecturer as something that could benefit from a different approach that the traditional lecture. All participants gathered together so they were in view on the projector in the lecture room. All participants were actively involved in the game from the start most drawing a map as they navigated the maze. The fact that most were drawing a map was exactly what the lecturer had wished for, as this map was the starting point for his lecture on navigation in networks.

The study demonstrated clearly that games designed for specific learning purposes without additional game-play can be engaging and motivating for participants and even this short game served its purpose of livening up a lecture. The cost of producing

such games however is high due to the fact that the ability to reuse the game is limited.

9 Results and analysis

The first four games studies supplied some interesting data. This chapter describes the analysis of the four different studies performed, which are described in chapters 5 through 8. The overall aim of the set of studies was to investigate different ways of combining a games environment with learning material. The conclusions from the findings and recommendations for a new prototype are at the end of the chapter.

The development process of the four games can be split into two methodologies. For the first two games, layering and embedding, the learning material was developed separately from the games elements, and only after the games environment was created the learning content was integrated. For the two last one and in particular the extrinsic bespoke game the learning material and the game had to be developed in tandem, requiring the game developer to be familiar with the learning material or have the lecturer present throughout the development of the game.

9.1 Study one: Layering learning material on top of a game

The prototype with Java content and with the learning material layered on top of a game is the first implementation of a design for a game based virtual learning environment the study is described in chapter 5. The prototype is tested using a group of first year students learning Java programming at University of Abertay Dundee. The focus of the testing is to determine the viability of a muli-level, multi-player gaming environment as a learning environment and to determine the issues in developing and presenting learning material within the environment. The prototype is created with a minimum of effort. The learning material is added on top of an existing games implementation resulting in the least amount of work, and no effort was made

to integrate the learning content into the existing game, other than answering questions on learning material gives useful items in game. As part of the set of studies it was created to evaluate if layering learning material on top of a game had any effect on the game-play.

This study demonstrated the use of a relatively simple game for learning, and as such might be regarded as trivial given the development of other games for learning over the years. However, this game has been developed to test the capability of a complex game-based learning environment, and to determine the level of sophistication necessary in the authoring of such games, to gain the known advantages of motivation and engagement engendered by games for entertainment.

The results found from the pre-questionnaire are: They ranked their programming knowledge on average and knowledge on methods in Java just below average. They enjoy programming they enjoy computer games even more and on the whole have a limited experience with computer games designed for learning. The informal feedback we had from participants during the 2 hour tutorial session where the participants were introduced to the environment was positive, and a number of them took down the address to download the client for use at home. The results found from the pre-questionnaire are not unexpected.

As part of the study the participants were asked to indicate how much effort is required before they can use this environment for learning, and the results is that of the 19 answers 2/3 indicated less than 5 minutes, 1/3 5-15 minutes, one student indicated 30-60 minutes. The finding here is that even though the participants in the

study are entered into a games environment they never used before, they have little problems and are capable of interacting with the learning material within a short period of time, in most cases less than 5 minutes.

As part of the study the participants were also asked whether they feel playing the game improved their knowledge, if they enjoy this form of learning, and if they find it useful. Overall the questionnaires in the studies shows that the participants felt that there was little benefit in this approach compared to traditional lecture/lab, they are more positive when they look at how useful they think environments like this are for learning, this may be connected to the fact that they enjoyed the overall experience. There is however obvious areas that need to be improved in future versions of the environment: the participants complained that too much time is taken up moving through the environment, and, interestingly, the lack of a direct link between Java and the quests.

The aim of the study was also to examine to what extent the participants help each other during the game, since MMORPG environments are known for their ability to create online communities, in which mutual help cultures amongst players are emergent. The logs after game did not show any significant communication, between the players in the game, most communication was on the form "Testing testing", "Hello can you read this?" It should be noted that all users of the environment is present in the same lab room during the trial, no players are located elsewhere.

The design decisions taken in developing the first prototype were focused on the development of the game infrastructure, the character set, and the navigation and

interaction mechanisms, and the learning material was intentionally layered on top of the game-play. This had two purposes, to test whether such an approach was acceptable to participants, who would make the reuse of game activity for different learning materials relatively easy, and to determine if this approach was a factor in the failure of a number of "games for learning" projects. The feedback from the participants demonstrated that they enjoyed and engaged with the game-play aspects of the game, but found the layering of learning material, rather than embedding, to be a negative aspect of the game. Tellingly, although they had reported enjoying the game, none of the participants returned to the environment after the initial two-hour session. The lack of participants returning cannot be attributed to a single factor, but it does seem likely that the dissatisfaction with the relationship between the learning material and the quests discouraged further play, especially given the fact that most players will revisit even the most trivial of games several times if they find the game-play enjoyable.

One working hypothesis is that the failure of many "games for learning" projects was as a result of failing to address the sophistication of the players in their reaction to the relationship between the learning materials and the game-play aspects of the game. This predicates a need to develop games in which the learning material is both embedded and inherent in the game-play, and the authors now intend to develop a second prototype addressing these points. Assuming such a prototype can encourage greater involvement by the participants with the environment, then we can also determine the socialisation and help activities within the player community, as within this first prototype the limited engagement of the participants resulted in the inbuilt chat system only being used in a very preliminary fashion.

9.2 Study two: Embedding learning material into a game

The second prototype was developed to provide an engaging games environments, in which we could investigate the value of such environments for learning, and particularly consider the impact of embedding of learning material within the game-play itself would have on the participants.

The participants using the second prototype were a group of Norwegian and Scottish students and the response to the pre questionnaire was much the same as with the first study.

The system also gathered information on when the participants logged in to the environment. The usage statistics show that, with a small number of exceptions, the Scottish participants never used the environment again after the initial two hour session. Of the Norwegian participants there were about 10 that actually used the environment and they all logged in over a period of two to three weeks on numerous occasions.

The lack of continued play by the participants is disappointing, as this suggests they did not find the prototype engaging enough to want to spend more time on it. However, it may also be argued that there was a need to create even greater levels of complexity in the prototypes, so that the participants wouldn't feel they had seen all the game had to offer in a two hour session. It is also somewhat more encouraging that those participants, who had downloaded the games onto their own machines in Norway, did interact with them much more and over a reasonable period. This does

suggest that there may well be a locational preference to be considered when using games-based learning environments, and it may be that participants don't feel engaged by the use of games in lab environments in the same way as they do when playing such games on their own computers in their own personal environments.

The examination on how much time participants used before they are capable of using the environment for learning did also show the same as with the first study, in most cases less than 15 minutes, all reported less than 30 minutes.

The lack of continued play by the participants and the fact that they all were located in the same lab during the trial lead to only a small amount of in game communication, so our investigation of to what extent the participants help each other during a game like this has not been completed. There were a significant amount of verbal communication between players in the lab during the trial, but none of this is in any way logged by the system.

The actual feedback from the participants from the questionnaires, albeit that the return from the second prototype was disappointing, is positive and encouraging. Half of the students found the game more beneficial for their learning than a regular lab class. Participants clearly find the idea of games-based learning strongly positive, and, despite not returning to use the games more, claimed to enjoy the experience when they did interact with the games. In terms of the impact of the level of embedding, there was some evidence to support the view that this has a significant impact on student learning, but there is a need for more feedback before any strong conclusions

can be drawn. However, these results do echo some of the studies on games that have been carried out, that enjoyment and flow can significantly improve learning uptake.

9.3 Study three: Learning content is modelled as quests and no pure game elements are added

The aim of this study is to show a prototype for a system that utilises games-based technology to support virtual learning environments that are constructivist in nature and utilise narrative for the learning process and assessment included as a continued process during the learning. The prototype is design use no pure games elements but rather to focus on creating a virtual environment and storyline using the learning content.

The results from the study are few, as the post questionnaire was not received from any participants, and that only a couple of participants logged into the system after the initial session, and on these occasions hardly any progression was made on the quests modelling the learning material.

The few comments made by the participants were positive, but most showed little interest. When questioned about the lack of interest the feedback from the participants was that the game was made available to close to the exam in the module and they elected to focus on traditional preparation to the exam.

9.4 Study four: Short multiuser game with quests used in as part of blended learning

The aim of this study is to investigate a prototype for a system that utilises games-based technology to support a blended learning environment. The prototype is designed to use no pure games elements but rather to focus on creating a virtual environment and storyline to support the learning activities. The modelling of the content in the game was developed as an abstraction of the learning topic focused on in the accompanying workshop. The conclusions draw from the participant's feedback in the study is that overall the participants felt that they learned just as much from participating in this study as from a traditional lecture/lab, but that they enjoyed this more, which met the requirement from the lecturer of greater engagement and increased motivation for the topic. The study also demonstrated that games designed for specific learning purposes without additional game-play can be engaging and motivating for participants.

9.5 Conclusions after the first four studies

The findings from the studies show that layering learning material on top of a game interferes with the game-play. This coupled with previous findings where games for learning has failed means that further investigation into this method of integrating learning material and game are not pursued.

Games created for bespoke for learning are known from previously investigation both to occasionally work and fail. In the reported studies one failed and one was successful, the major issues with these games are however the amount of work that goes into the creation of them and the lack of reuse they offer. Both of these games

was created from a blank world, both of the two other games was able to utilise large amount of the sample code offered by the development environment.

The study investigating the integrating of learning material and game-play though not particularly successful showed signs of behaviour from the participants that were desired. Some participants used the environment on multiple occasions and the feedback on the learning material was good. A decision that further investigation into a second version of this environment with embedded learning material is warranted. This new version of the environment must be with enriched with more game elements and a generally richer environment in all aspects. The decision that the learning content should be left unchanged from the first version was taken. This richer environment though still very limited in area is much more in line with what would be found in an equivalent part of a commercial game of this type.

The focus of the testing for this second version is to repeat the testing done on the first version aim to try to establish how important the amount of game-play is for learning environments of this type. The aim was also to encourage students to help each other during the game, since as mentions previously MMORPG environments are known for their ability to create online communities, in which mutual help cultures amongst players are emergent.

10 Study five: Study two second version: Learning content is modelled as quests into a game

The study described in this chapter is based on conclusions drawn from the previous studies, and described in chapter 9. The game is a new version of the game described in chapter 6, learning content is modelled as quests into a game, and the learning content is C++ programming. The second version of this environment is enriched with more game elements and is a generally richer environment in all aspects except that the learning content is unchanged from the first version.

The focus of the testing is to repeat the testing done on the first version, to determine the viability of a multi-level, multi-player gaming environment as a learning environment and to determine the issues in developing and presenting learning material within the environment, in addition the study aim to try to establish how important the amount of game-play is for learning environments of this type.

A secondary aim is to determine if students can be encouraged to help each other during the game, for this and practical reasons the help offered to the participants was more focused on in game help and not so much physical presence in the lab.

The participants in the second study are equivalent to the Scottish group of participants in the first version of the environment, a group of first year students learning C++ programming at University of Abertay Dundee.

10.1 Content

10.1.1 Learning content in the C++ environment

Learning content in the second version is the same as the first version, only minor alteration has been made to some of the feedback given by NPCs to the players.

10.1.2 Design of the environment

The prototype for the current study has been enriched with more game elements. These game elements that are added are:

- Higher number of enemies to fight
- More types of enemies
- More types of armour
- Possibility to create alliances and cooperate when fighting
- Change in some of the rewards, most notability upon completion of the final quest the participants are not awarded a diamond, but are now awarded a ring that when worn enabled the participant to fly.

The main aim is to establish how important the amount of game-play is for learning environments of this type. The extra amount of gaming elements are added in order to enrich the environment, most added elements are available in the early version of the environment, the focus has been on adding more of the same.

The rationale behind adding more of the same is to enable more participants the possibility to play and fight simultaneously in addition the participants that do fight have a richer selections of enemies to fight. The fighting elements are included to allow the participants to get an occasional "kick" from fighting, when they so desire.

10.2 Trials

A group of 49 students in the first year computer games development course doing a module on C++ programming participated in the test of the environment. The environment was introduced to the participants in a standard 2 hour tutorial. A short movie demonstration was shown to the participants to show how to log inn and create a character, after this all help was intended to be delivered inside the environment. The participants were also given a pre-questionnaire that took between 1 and 5 minutes to fill in. For the rest of the two hour slot the participants were allowed to try out the environment. The lecturer of the C++ module where present to answer any questions the participants had. In a change from the other prototypes the developer of the environment was only available online in the game, as he was in Norway during the trials.

10.3 Results

After the initial session all the participants were e-mailed a questionnaire and kindly asked to answer it, several reminders later all the participants has handed in the questionnaire.

Question	Average	Very little	Not much	Average	Quite a lot	Lots	Answered by
How would you rate your knowledge in programming so far	3,15	1	9	23	12	3	48
How much do you enjoy programming	4,10	0	1	10	21	17	49
Have you any previous experience with computer games	4,61	0	0	5	9	35	49
How much do you enjoy playing computer games	4,63	0	0	4	10	35	49
Have you any previous experience with MMORPG (Massive multiplayer online Role playing Games)	3,24	5	12	12	6	14	49
How much experience do you have with games designed for learning	2,47	5	20	20	4	0	49
How good in your opinion have the games designed for learning you have seen been to play	2,44	8	13	25	2	0	48

Table 10-1 Results from the pre questionnaire C++ version 2

Question	Average	Very little	Not much	Average	Quite a lot	Lots	Answered by
Do you feel playing the game improved your knowledge of C++?	2,49	4	18	20	3	0	45
Did the game give you any benefit compared to traditional lecture/lab	2,70	3	16	19	8	0	46
How much did you enjoy playing the game	3,44	1	5	18	20	4	48
How much did other students help you during the game	2,11	15	18	8	6	0	47
Did you have any difficulty navigating the game	2,33	10	19	13	5	1	48
How important was the introduction by the lecturer before playing the game	2,58	7	13	21	7	0	48
If you did the final assessment how difficult did you find it	2,62	2	2	8	1	0	13
Having played the game how useful do you think games like this are for learning	3,40	1	4	20	21	2	48
		0-5 min	5-15 m	15-30m	30-60m	1h ->	
How much time did you spend learning the environment before you could play	1,63	22	14	4	0	1	41

Table 10-2 Results from the post questionnaire C++ version 2

10.3.1 Logged results

The system logs all data of the players in the database, and makes a copy of this every hour that the system is running, usage statistics have been logged for all studies in this way. The system logs all information about what items and experience points a specific toon has. A toon is one specific avatar for one participant, all participants may have multiple toons. There may be multiple reasons for having multiple toons: Every toon is allowed to attempt the multiple questions once, and only once, so a desire to redo the whole game or failure to achieve enough correct answers to be able to continue results in the participant needs to go back and start from the beginning with a new toon.

The data allows us to track two types of activities by the participants: changes in experience points and changes in items carried.

Changes in experience points: mean that the player has been involved in killing enemies and or other participants (who are willing to engage in PvP[1]).

Changes in items carried: at least in particular quest related items, indicate progression on quests connected to the learning material.

Of all the participants in the study eight have returned to environment after the initial session. More that the eight participants may have logged in after the initial session , but they have not progressed any further in the game, and so they are registered as not to have returned. Of the eight returning participants:

- 1 progressed only on quests that contains the learning material
- 5 participants progressed both on learning material and in the game

2 return to play, and did not progress any further in the learning material

A compressed view of the data collected for the 8 returning participants is included in appendix C.

10.3.2 Observed results (activity and in game chat)

The study was run with a tutor and a couple of student helpers present in the lab during the study. The student helpers had all been introduced to the environment a few days before the start of the study, and though they were present in the lab they were also logged in to the environment and supplied the help in the environment, in

[1] PvP: Player versus Player. Both participants must go into the setup and select that they wish to enter PvP modus, only when both participants are in PvP ,may they actually attack each other.

addition to some assistance to a couple of participants with the login procedure was given.

The students in the module on C++ programming are divided into tutorial groups. Participants in the study used an assigned tutorial slot for the initial two hour session, some participants logged on in more than one of these sessions.

The observed activity in the environment at other times than these initial sessions was low, with a maximum of 5 participants registered at any time. In comparison the activity in and around the initial session was up to 50 participants.

The communication between participants in the environment is via chat system, and a few gestures and movements of the avatars. As noted earlier the developer of the environment was not available in the lab but logged into the environment from his office in Norway. The participants there for had to ask and receive help through the environment in the cases where the student helpers in the lab was unable to respond or was otherwise occupied. This was done mainly to encourage communication and socialisation. In addition it had the effect of showing that the environment can be picked up and used without any expert present.

In the sessions with a fair amount of users, in this case more that about 15, the communication between participants was present. Initially the communication was of the type "Hello, is this working" after a short while the communication changed in nature and became the more usual in MMORPG's, participants posted comments, questions, asked for help, replies and tips was posted as responses to these questions.

The expectation was for the developer and a possibly a couple of the students helpers to respond to questions, but as the session's progressed it became clear that several of the participants were familiar with standard MMORPG play and numerous occasions responded to fellow participants questions quicker than students helpers and the developer. Often resulting in multiple answers to a single question, a scenario often observed in MMORPG's.

10.4 Analysis

This study was designed to see if with an environment that has been enriched with more game elements and a generally richer environment may create increased levels of the desired engagement resulting in some elements of reuse and socialisation. Thereby helping to establish what level of embedding of that material is necessary within a game, and when incorporating learning content into a game, or designing a game for learning purpose, what works best and what is the threshold on game-play? Basically what works and what does not work?

At least 8 of the 48 participants in the study returned to environment after the initial session, so 1 in 6 participants returned. Most of the participants that returned both progressed in the learning material and played the game, only two returned just to play.

The participants in the study had to ask and receive help through the environment in the cases where the student helpers in the lab were unable to respond or were otherwise occupied.

There are emerging signs of socialisation, at times, when there was a sufficient number of simultaneous users, in this case about 15, there were multiple occurrences where the participants help others participants. It is expected and documented with the pre-questionnaire that some participants have more experience with MMORPG's than others. The participants with more experience will be able to help others simply because in all MMORPG games there are similarities, in addition these participants will also be familiar with the basic concept that MMORPG players help each other constantly during the game, thereby lowering the threshold for answering the other participant's questions.

11 A methodological approach for successful integration of games and learning material

This chapter describes a methodology for integrating learning material into computer games for multiple target audiences. As per the previous Chapters, the chosen approach to integrating learning material within a games context is embedding.

The task of creating successful games with integrated learning material is not an easy one, in fact it is even more complex than that which game developers regularly face. The two main challenges in game design are the graphical elements and the game-play. Nice graphics and interesting user interface detail draw people into a game and good game-play gets the players to return to the game again and again. Creating a game for learning, developers have the additional challenge of integrating well-designed learning materials into the game.

The studies reported in previous Chapters show that learning material needs to be embedded into a game, rather than just layered on top. In addition the game has to have both sufficient richness and good game-play for the students to be sufficiently motivated and engaged to revisit and reengage with it.

There have been numerous failures, but also noted successes, in games created for learning. Perhaps the main challenges with games created for learning, and games in general, are the associated cost and uncertainty of success. No-one seems to have been able to develop a design methodology that will repeatedly create good game-play, or even that has a method of determining with any degree of certainty if a game will

have good game-play. The types of games for learning under discussion here are dependent on the players returning and reengaging with the learning material to be successful. One crucial factor for this success is that the game has good game-play.

In addition to creating a game with good game-play with embedded learning material, it must be recognised that the game will be only one type of game suited for only one target audience. It is well-documented within the gaming industry that different groups of people enjoy different types of games. These different groups are differentiated by gender type, age group, personality and a number of other factors which are the subject of considerable current research. The traditional perception that it is just teenage boys who plays games is wrong, a study by the Entertainment Software Association[142] in 2009 shows that 40% of game players are female and of the online players this figure increases to 43%. It is important to remember that to get different groups of players to engage with the learning content in a game, different games, containing that learning content, must be created and tailored to the different target groups. The video game industry is constantly developing better information on video game demographics, and this information that may be utilised to create an individual game with learning content matched to a specific target group of students, or alternatively multiple games for different sub groups within the student group.

Bearing all this in mind, there will be two groups of specialists involved in the creating of a game for learning: the subject specialists creating the learning material, and the game developers creating or adapting the games that are to be integrated with the learning material.

11.1 Development of learning material

The development of the learning materials must be undertaken by subject specialists, and should be developed in a standardised and reusable form, such as the IEEE LOM. The developed material must be parameterised in order to allow learning objects to be embedded either whole or in part into the games created by the games developers. Following on from the conceptual design presented in chapter 3 and the work done in creating the prototypes certain elements will be required:

- The first elements to be created will be the static information that the subject specialists wish to be presented to the players. Representation of the material can be in one or more formats, video and/or audio, text, pictures, and so on, the only requirement being that it is possible to present it to the players within the environment.
- The structure of the learning material should be divided into levels based on topics and sub-topics, to aid in the navigation for the players and help with later integration into a games context.
- There must also be devised a set of rewards that are available to the player during game-play. These items represent concepts to use later in the game or in the assessment phase.
- Assessment & Reassessment: There must be a predetermined structure on how to perform assessment and thereby allowing the players to move on to higher levels in the game. The issues of failing the assessment and how reassessment is dealt with must also be part of this structure.
- The issues of how to allow the players to communicate and how they should help each other must be planned and then later implemented as part of the game structure. Most online games today have some form of in-game chat. In

planning the game, decisions need to be made on online and/or offline communication and if there is a need/desire for any formal group tasks and other cooperation in the game

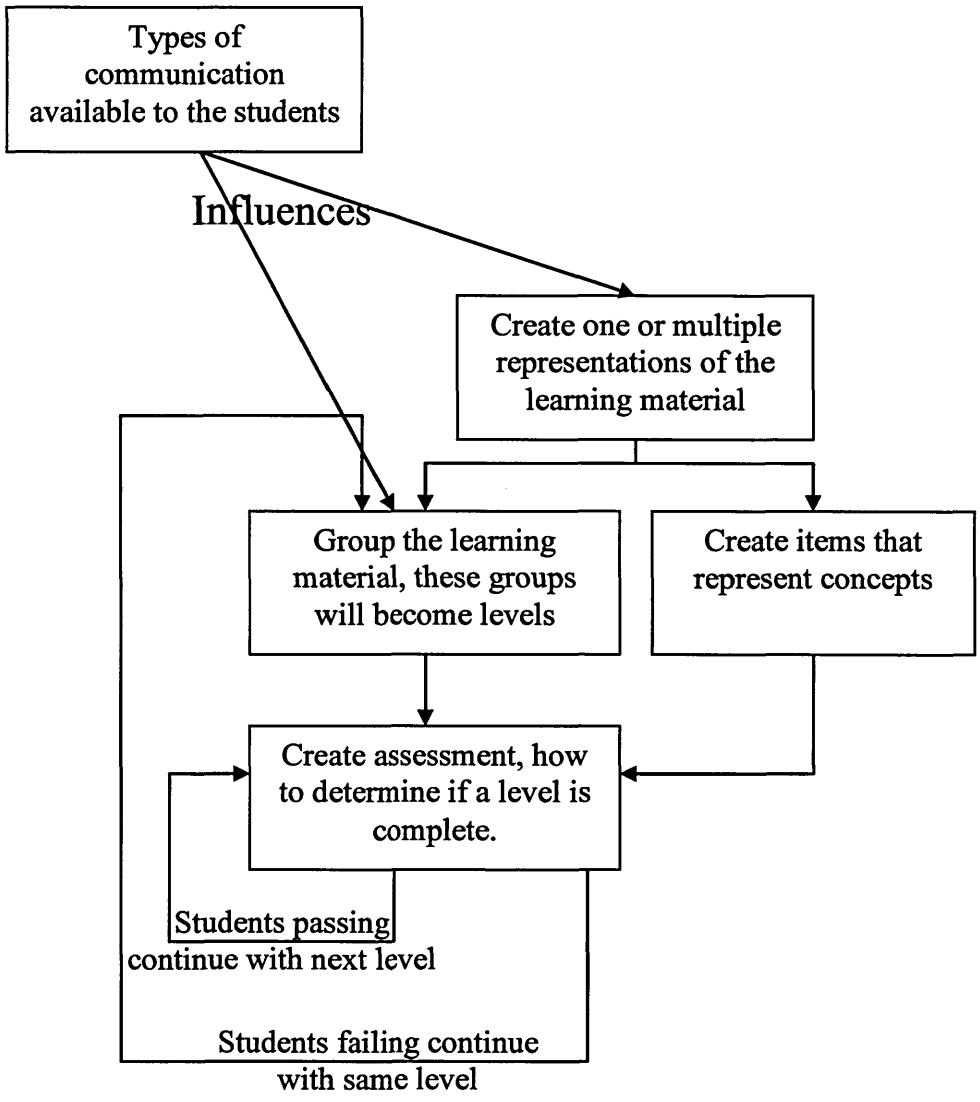

Figure 11-1 Creation of learning material for the games based learning environment

The design, creation and structuring of the learning materials outlined in the tasks above can be completed independent of any game content, and as such should be separated out and developed using different tools than those used for creating the game itself. The learning content should be created as learning objects, with the

additional information for integration in a games environment added as meta-data. This will require an authoring environment that can support the authoring of these learning objects and export them in a format suitable for integration with the games content.

11.2 Development or alteration of games with good game-play

The requirements for the game designers and developers will be first and foremost to create or adapt a game with proven good game-play. This game will have to be created or modified to accommodate the elements described in the previous section:

- Ways to present the learning material the subject specialists wish to be presented to the players.
- Multiple levels or similar to facilitate the division of the learning material in topics, this division must be able to match what the subject specialists have created. Or the subject specialists must match what is possible in the game.
- Items that can be used for rewards, somewhere to store these items and a way to keep track of the progress in the learning material. This can be separate from or the same as the score points in the game.
- Assessment & Reassessment: There must be inbuilt assessment and reassessment that controls the access to the different levels within the game. The game must be able to accommodate the assessment described by the subject specialist, preferably via automated assessment.
- Communication for socialisation and cooperation including the possibility for formal or informal group tasks needs to be modelled into the game, when this is a requirement either by the subject specialist or by the content developer.

The most labour intensive task is the initial creation of a game with proven good game-play, and this task can be completed without considering any of the learning material that later will be integrated into the game. There will be some extra requirements during the creation of the game elements, such as levels, items, and socialisation facilities, but these should not be major limiting factors on the game developers.

There will be a need to create a set of games matching these guidelines for different demographics. The existence of a set of different games designed for these differing demographics will offer the possibility to integrate the learning material with a game aimed at a particular type of user. It will also give the possibility to easily create a set of games based on the same learning content providing coverage for a wide range of different types of users.

11.3 Bringing game and learning material together

Once the subject specialist has created the learning content, integrating a pre-made game and this learning content requires a few steps.

First, a game must be selected based on the demographics of the student group, in heterogeneous groups this may result in a set of games being selected.
The task of embedding the learning content into the pre-designed game(s), needs to be performed after the game is chosen and the learning material is created. This finished game must then be verified by the subject specialist, before release.

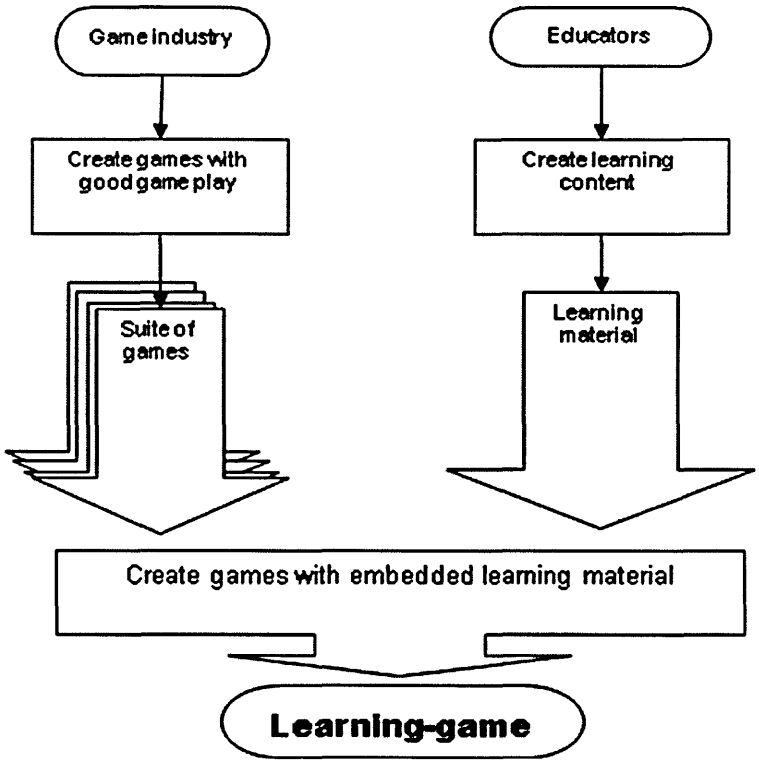

Figure 11-2 Methodology for integrating games and learning material

The split described above with two distinct routes for game development and learning material authoring will make the process easier to manage, as the experts will be able to operate in their separate subject areas when material is created. The fact that we can allow the games developers and subject specialists to work independently should be a contributing factor in making the development as efficient as possible. This division can be accomplished only if a predetermined interface between the game and learning content is agreed upon before the work commences. The definition of this interface is beyond the scope of this thesis, but the included guidelines for the learning material and game gives an overview of the main points that such an interface must cover, and the use of a standard model for a learning object, such as the IEEE LOM, will provide clarity in the interface and content specification. It should be noted that no such standards exist in the games industry, so standardisation must be introduced through the learning material authoring process.

12 Conclusions

The focus of the investigations and the research presented in this thesis is to use a games based virtual learning environment as a delivery vehicle for learning objects, while retaining good game-play, with the evidence of that good game-play coming from observed reuse and socialisation.

The initial aims and objectives for the research was the creation of a new or the enhancement of an existing virtual learning environment with added features such as inbuilt support for constructivist pedagogy and computer games elements to create engagement and motivate the students. The task undertaken in order to fulfil these aims were a literature review and the creation of a conceptual design for such a game based learning environment and the identification of a suitable development platform as a basis for prototype implementations to test whether such a games-based environment is a viable way to present learning material for higher education. The reasoning behind the requirement for supporting games based metaphors and underpinning models are their ability to engage, reinforce, and support multimodality and socialisation, and because they are inherently constructivist.

I became clear through the literature review and after the conceptual design was created that extending a VLE to support games based learning were not a viable option and initial the null hypothesis was proven that "It is neither feasible nor effective to develop games-based learning activities using existing VLE and learning object technologies, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play."

This lead to a new hypothesis that "A methodology can be devised to incorporate learning activities and objects into existing games, with proven game-play, rendered within a games engine enhanced as a learning environment, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play."

The work to prove this new hypothesis was pursued through the building of several prototype environments based on a Games Engine. Additionally, work on these prototypes included a consideration of the integration of assessment into the learning environment, initially utilising plagiarism tools to offer automated assessment. An investigation into the use of plagiarism tools to offer automated assessment capabilities was carried out. The investigation showed that the tools investigated do not offer enough richness and fuzziness to be useful for quick assessment and feedback on student created narrative in a games environment. The prototypes created were therefore given the facility to allow an e-mail with any text desired to be e-mailed to a tutor for marking. The results of this marking did not influence the progression in any of the prototypes created.

A series of studies were carried out, each designed to address a particular approach to the integration of learning materials with game-play. The work on the prototypes for the studies was guided by the requirement to the design of the games based learning environment that it must support all the expected capabilities and functions of a standard Games Engine, this to ensure that the games offered within the environment can be used and reused by the participants. It is known from educational research over

many years that the effect of repeated exposure to the same information again and again ensures that the information is retained and this aid in understanding and learning. Deep learning requires the commitment of time and effort. The studies was not be set up to test learning and retention, because it is known from learning theory that reuse and re-visitation on learning material enhances learning. The research was focused on investigating a model that will encourage a significant level of the students to return and reuse the game, and interact with the community of learners in the game. The results collected are both logs from actual use by the students and subjective feedback as to whether they found the game engaging.

Four different approaches to integration was investigated, the most promising of the approaches, embedding learning material into a game was investigated twice, the second time with a richer games environment. The initial study was not able to create the desired engagement resulting in reuse and socialisation, whereas this second environment managed to create increased levels of reuse and socialisation. The two studies were thus a big help in establishing what level of embedding of that material is necessary within a game, and what levels of richness and size of games area are required to create motivation and engagement. From this a methodological approach to the development of games for learning has been developed and described in Chapter 11, thus proving the hypothesis that "A methodology can be devised to incorporate learning activities and objects into existing games, with proven game-play, rendered within a games engine enhanced as a learning environment, which will invest those learning activities with the known benefits of motivation and engagement invoked by game-play."

The contributions to the body of knowledge shown in this thesis are:

- First and foremost a new methodological approach to the development of games for learning has been described.
- Inherent in this methodology is a qualitative analysis of different approaches to the development of games for learning, which identified two primary models. In one model the game is built for purpose and this requires games developers and subject specialist to work tightly together through the development phase, which is inherently expensive but can work. The other model identified is that of embedding learning material into a pre-existing game, which has already been demonstrated to have good game-play, which has the advantage of reuse and the separation of the content development from the game development, and also allows for the use of existing authoring tools for learning objects.
- A design for an online assessment mechanism to integrate into a games based environment is also described and some initial investigation into the possibility of automating this assessment approach using plagiarism tools.

The contributions are also described in 8 peer reviewed conference articles and 3 peer reviewed journal articles identified earlier, these have been widely cited and as a result further ongoing research derives from these.

12.1 Further work

The results show that there is the potential to further explore the use of an embedding methodology to place learning content into pre-designed games. The presented methodological approach could be developed into an authoring tool to embed learning content into those pre-designed games, and assist the developers in the process. That

tool should help the users to select the "correct" game from the suite of available games and combine this game with the learning material, in the form of learning objects. It should then assist in the process to combine one or more selected games with the learning content, thereby creating games for learning.

The research in this thesis has demonstrated that this approach can result in the requisite levels of reuse and socialisation, and is it now possible to utilise an embedding methodology to place learning content into pre-designed games. There is however a need for professional games developers to design and develop a suite of games of different types for different target audiences with focus on good game-play. These games can then be tested as pure entertainment games and it would therefore be possible to verify that the game-play is successful before they are integrated with learning material.

Subject specialists will have a task of creating learning content. This learning content must be appropriately tailored for embedding into the games created by the games developers. The creation of this learning content should be in the form of learning objects and can be done completely independent of any game content, which will require the creation of a new authoring tool or the adaptation of an existing one. The authoring tool for these learning objects needs to be able to aid in the creation of any additional information required by the learning environment, and to export them in a format suitable for integration with the pre-created games.

Further studies are also needed on the use of this methodological approach, to establish the effectiveness and suitability of different types of games, and to evaluate it in use by a range of academic staff.

An investigation into the learning outcomes, to establish how effective the different techniques for creating learning environments are, should also be performed, as the research presented here does not attempt to investigate the effectiveness of the described approach in terms of learning outcomes.

An investigation of the potential challenge of locational preference noted in chapter 9.2 during the analysis of the study described in chapter 6 embedding of learning material., should be investigated further. Do the location, lab equipment in a lab environments vs. their own computers in their own personal environments, influence how engaged they become when playing computer games?

The investigation into assessment and automation of assessment are far from completed. Both the implementation of "student-created narrative-based assessment" in a game based environment, and automated assessment, are areas that would benefit from further work. The use of lexical analysis/tokeniser tools, such as those used for plagiarism detection in source code analysis, proximity analysis, and existing automated essay marking tools should all be investigated in terms of their effectiveness and their suitability for inclusion in a games environment.

13 References

[1] L. Henderson, "Video Games: A Significant Cognitive Artifact of Contemporary Youth Culture," in DiGRA. Vancouver, Canada, 2005.
[2] O. H. Graven and L. M. MacKinnon, "A survey of current state of the art support for lifelong learning," in ITHET. Juan Dolio, Dominican Republic: IEEE Press, 2005.
[3] O. H. Graven and L. M. MacKinnon, "Games based support for lifelong learning," in REV. Porto, Potugal: International Associsiation of Online Engineers, 2007.
[4] O. H. Graven and L. M. MacKinnon, "Exploitation of games and virtual environments for e-learning," presented at ITHET, Sydney, Australia, 2006.
[5] O. H. Graven and L. M. MacKinnon, "Student-created Narrative-based Assessment," in eLearn. Honolulu, Hawaii, US: AACE Press, 2006.
[6] O. H. Graven and L. M. MacKinnon, "A consideration of the use of plagiarism tools for automated student assessment," IEEE Transactions on Education, vol. 51, pp. 212-219, 2008.
[7] O. H. Graven and L. M. MacKinnon, "Prototyping a Games-Based Environment for Learning," in eLearn. Las Vegas, US: AACE Press, 2008.
[8] O. H. Graven and L. MacKinnon, "Prototyping Games-Based Environments for learning C++ programming," presented at HCI Educators, Dundee, UK, 2009.
[9] O. H. Graven, D. Samuelsen, and L. M. MacKinnon, "Games-based environment for e-learning in analogue electronics," in ICL. Villach, Austria: International Associsiation of Online Engineers, 2008.
[10] O. H. Graven, D. Samuelsen, and L. M. MacKinnon, "Computer-based Role Playing Game Environment for analogue electronics," International Journal of Online Engineering, vol. 5, pp. 27-33, 2009.
[11] O. H. Graven, H. A. Hansen, and L. M. MacKinnon, "A Blended Learning Exercise using a Computer Game based on Abstract Learning Materials," in ICL. Villach, Austria: International Associsiation of Online Engineers, 2009.
[12] O. H. Graven, H. A. Hansen, and L. M. MacKinnon, "A computer game modelling routing in computer networks as abstract learning material in a blended learning environment," International Journal of Emerging Technologies in Learning, vol. in print,, 2009.
[13] Learning Technology Standards Committee, " IEEE Standard for Learning Object Metadata," IEEE Technical Report 1484.12.1-2002, 2002.
[14] IMS, "IMS Global Learning Consortium," http://www.imsglobal.org/, Last visited 30.September.2009.
[15] D. E. Leidner and S. L. Jarvenpaa, "The use of information technology to enhance management school education: A theoretical view," MIS Quart, 1995.
[16] M. Tam, "Constructivism, Instructional Design, and Technology: Implications for Transforming Distance Learning," Educational Technology & Society, vol. 2 2000.
[17] J. J. Haney, A. T. Lumpe, and C. M. Czerniak, "Constructivist Beliefs about the Science Classroom Learning Environment: Perspectives from Teachers, Administrators, Parents, Community Members, and Students," School Science and Mathematics, vol. 103, 2003.

[18] J. M. Ferreira, L. MacKinnon, Ø. Ra, and e. al, "The ASTEP distributed framework for teaching and learning," in 4th European Forum for Continuing Engineering Education, 1999.
[19] J. T. Mayes, "Dialogue with a dumb terminal," in Times Higher Education Supplement October 10th, 1997.
[20] A. P. Rovai, "Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks.," The Internet and Higher education, vol. 5, pp. 319-332, 2002.
[21] J. B. Biggs, Teaching for quality learning at university : what the student does, 2nd ed. Phildelphia, Pa.: Society for Research into Higher Education : Open University Press, 2003.
[22] J. S. Bruner, "The act of discovery," Harvard Educational Review vol. 31, pp. 21–32, 1961.
[23] Thirteen ed online: http://www.thirteen.org/edonline/concept2class/constructivism/index_sub6.html, Last visited 30.September.2009.
[24] S. M. M. Loyens and D. Gijbels2, "Understanding the effects of constructivist learning environments: introducing a multi-directional approach," Instructional Science, vol. 36, pp. 351-357, 2008.
[25] P. C. Blumenfeld, "Classroom Learning and Motivation - Clarifying and Expanding Goal Theory," Journal of Educational Psychology, vol. 84, pp. 272-281, 1992.
[26] D. J. Cunningham, "Beyond educational psychology: Steps toward an educational semiotic.," Educational Psychology Review, vol. 4, pp. 165–194, 1992.
[27] L. S. Vygotsky and M. Cole, Mind in society : the development of higher psychological processes. Cambridge, Mass.: Harvard University Press, 1978.
[28] R. G. Tharp and R. Gallimore, Rousing minds to life : teaching, learning, and schooling in social context. Cambridge: Cambridge University Press, 1988.
[29] D. Wood, J. Bruner, and G. Ross, "The role of tutoring in problem solving," Journal of child psychology and psychiatry, vol. 17, pp. 89-100, 1976.
[30] T. Boyle, "Towards a theoretical base for educational multimedia design," Journal of Interactive media in Education, vol. 2, 2002.
[31] T. Boyle, Design for multimedia learning. London: Prentice Hall, 1997.
[32] D. A. Kolb, Experiential learning : experience as the source of learning and development. Englewood Cliffs, N.J.: Prentice-Hall, 1984.
[33] P. Honey and A. Mumford, The manual of learning styles. Maidenhead, Berkshire: P. Honey, 1992.
[34] R. J. Sternberg, Thinking styles. Cambridge: Cambridge University Press, 1997.
[35] N. D. Fleming and C. Mills, "Not Another Inventory, Rather a Catalyst for Reflection," To Improve the Academy, vol. 11, pp. 137., 1992.
[36] E. Uruchrutu, L. MacKinnon, and R. Rist, "User Cognitive Style and Interface Design for Personal, Adaptive Learning. What to Model?," in User Modeling 2005, vol. 3538/2005, L. Ardissono, P. Brna, and A. Mitrovic, Eds.: Springer Berlin / Heidelberg, 2005, pp. 154 – 163.
[37] D. Boud, "Assessment and Learning: contradictory or complementary?," ssessment for Learning in Higher education, pp. 35-48, 1995.
[38] F. Marton and R. Saljo, "On qualitative differences in learning I. Outcome and process," British Journal of Educational Psychology vol. 46, 1976.

[39] P. McKenna and B. Laycook, "Constructivist or Instructivist: Pedagogical concepts practically applied to a computer learning environment," in ITICSE'04. Leeds, UK, 2004.
[40] D. Boud, "Assessment and the Promotion of Academic Values," Studies in Higher Education, vol. 15, pp. 101-111, 1990.
[41] Y. Cho, "Assessing writing: Are we bound by only one method," Assessing writing, vol. 8, pp. 165-191, 2003.
[42] C. Bereiter and M. Scardamalia, The psychology of written composition. Hillsdale, N.J.: L. Erlbaum Associates, 1987.
[43] V. Berninger, D. Whitaker, Y. Feng, H. L. Swanson, and R. D. Abbott, "Assessment of Planning, Translating, and Revising in Junior High Writers," Journal of School Psychology, vol. 34, pp. 23-52, 1996.
[44] D. E. Powers and M. E. Fowles, "Effects of applying different time limits to a proposed GRE writing test," Journal of Educational Measurement, vol. 33, pp. 433-452, 1996.
[45] T. D. Praetere, "E-learning Learning through the use of electronic devices.," http://knol.google.com/k/thomas-de-praetere/e-learning/20ohkjtmn38cb/2#, Last visited 30.September.2009.
[46] A. A. Hamid, "E-Learning Is it the e or the learning that matters?," The Internet and Higher education, vol. 4, 2001.
[47] Microsoft, "Microsoft office," http://office.microsoft.com, Last visited 30.September.2009.
[48] Macromedia, "Macromedia Dreamweaver," http://www.macromedia.com/software/dreamweaver, Last visited 30.September.2009.
[49] Macromedia, "Macromedia elearning," http://www.macromedia.com/resources/elearning/?promoid=BINE, Last visited 30.September.2009.
[50] Macromedia, "Macromedia Flash," http://www.macromedia.com/software/flash/flashpro/?promoid=BINT, Last visited 30.September.2009.
[51] WebCT: http://www.webct.com/, Last visited 30.September.2009.
[52] Blackboard, "Blackboard," http://www.blackboard.com, Last visited 30.September.2009.
[53] Moodle: http://moodle.org/, Last visited 30.September.2009.
[54] Sakai: http://www.sakaiproject.org/, Last visited 30.September.2009.
[55] T. Govindasamy, "Successful implementation of e-Learning Pedagogical considerations," The Internet and Higher education, vol. 4, pp. 287-299, 2001.
[56] C. R. Graham, "Blended learning systems: Definition, current trends, and future directions," in Handbook of blended learning: Global perspectives, local designs., C. J. Bonk and C. R. Graham, Eds.: Pfeiffer, 2005, pp. 3-21.
[57] R. Woods, J. D. Baker, and D. Hopper, "Hybrid structures: Faculty use and perception of web-based courseware as a supplement to face-to-face instruction," The internt and higher education, vol. 7, pp. 281–297, 2004.
[58] O. H. Graven, M. Helland, and L. M. MacKinnon, "The influence of staff use of a virtual learning environment on student satisfaction," in ITHET. Sydney, Australia: IEEE Press, 2006.
[59] A. Caspi, P. Gorsky, and E. Chajut, "The influence of group size on nonmandatory asychronous instructional discussion groups," The Internet and Higher Education, vol. 6, 2003.

[60] J. Bluemink and S. Järvelä, "Face-to.face encounters as contextual support for Web-based discussions in a teacher education course," The internet and higher education, vol. 7, 2004.
[61] J. T. Mayes, F. Dineen, J. McKendree, and J. Lee, "Learning from watching others learn," in Networked Learning: Perspectives and Issues, C. Steeples and C. Jones, Eds.: Springer, 2001.
[62] T. Schellens and M. Valcke, "Fostering knowledge construction in university students through asynchronous discussion groups," Computers & Education, 2005.
[63] M. Khalifa and R. Lam, "Web-based Learning: Effects on learning process and outcome," IEEE Transaction on education, vol. 45, pp. 350-356, 2002.
[64] A. S. Gibbons and J. Nelson, "The Nature and Origin of Instructional Objects," in The Instructional Use of Learning Objects, R. Richards, Ed.: Agency for Instructional Technology, 2002.
[65] Ariadne, "ARIADNE foundation," http://www.ariadne-eu.org/, Last visited 30.September.2009.
[66] KOD, "KOD - Knowledge on Demand," http://kod.iti.gr/, Last visited 30.September.2009.
[67] 3DE, "3DE-Design Development and Delivery Electronic Environment for Educational Multimedia," http://www.3deproject.com/, Last visited 20.October.2008.
[68] I. Sommerville, Software engineering, 6th ed. Harlow: Addison-Wesley, 2001.
[69] P. Coad and E. Yourdon, Object-oriented analysis, 2nd ed. Englewood Cliffs, N.J.: Yourdon Press, 1991.
[70] T. Boyle, "Design principles for authoring dynamic, reusable learning objects," Australian Journal of Educational Technology, vol. 19, pp. 46-58, 2003.
[71] D. A. Wiley, Connecting learning objects to instructional theory: A definition, a metaphor and a taxonomy.: Online book http://www.reusability.org/read, 2001.
[72] Dublin, "Dublin Core Metadata Initiative ": http://dublincore.org/, Last visited 30.September.2009.
[73] SCORM - Sharable Content Object Reference Model http://www.adlnet.org/Technologies/scorm/default.aspx, Last visited 10.October.2009.
[74] Ali Türker, I. Görgün, and O. Conlan, "The Challenge of Content Creation to facilitate Personalized eLearning Experiences," International Journal on E-Learning, vol. 5, pp. 11-17, 2006.
[75] iClass, "Intelligent distributed cognitive-based open learning system for schools," http://www.iclass.info/iclass01.asp, Last visited 03.September.2009.
[76] P. Vandepitte, L. V. Rentergem, E. Duval, S. Ternier, and P. Neven, "Bridging an LCMS and an LMS: a Blackboard Building Block for the ARIADNE Knowledge Pool System," in ED-MEDIA, 2003.
[77] J. B. Arbaugh, "Learning to learn online: A study of perceptual changes between multiple online course experiences," The internet and higher education, vol. 7, 2004.
[78] Y. Levy, "Comparing dropouts and persistence in e-learning courses," Computers & education, 2005.
[79] S. Rodríguez, J. Zamoranoa, F. Rosalesa, A. G. Dopicoa, and J. L. Pedrazaa, "A framework for lab work management in mass courses. Application to Low Level Input/Output without hardware," Computers & Education, vol. 48, pp. 153-170, 2005.
[80] D. Samuelsen and O. H. Graven, "Low cost robots used for practical assignments in programming modules," in iecon. Porto, Potrugal: IEEE, 2009.

[81] T. Kikuchi, S. Fukuda, A. Fukuzaki, Keizo Nagaoka, K. Tanaka, T. Kenjo, and D. A. Harris, "DVTS-Based remote laboratory across the Pacific Over the Gigabit network," IEEE Transaction on education, vol. 46, 2003.
[82] P. Sánchez, B. Alvarez, A. Iborra, J. M. Fernández-Meroño, and J. A. Pastor, "Web-Based Activities Around a Digital Model Railroad Platform," IEEE Transaction on education, vol. 46, 2003.
[83] M. Casini, D. Prattichizzo, and Antonio Vicino, "The Automatic Control Telelab: A User-Friendly Interface for Distance Learning," IEEE Transaction on education, vol. 46, 2003.
[84] J. Machotka, Z. Nedic, and Ö. Göl, "Collaborativelearning in the remote laboratory NetLab," Journal of Systemics,Cybernetics and Informatics, vol. 6, pp. 22-27, 2008.
[85] D. Müller and J. M. Ferreira, "Online labs and the MARVEL experience," International Journal of Online Engineering, vol. 1, 2005.
[86] C. Bhunia, Giri, S, Kar,S, Haldar, S & Purkait, P, "A Low-Cost PC-Based Virtual Oscilloscope," IEEE Transactions on education, vol. Vol 47, 2004

[87] G. Rafe, E, Needy, K,L, Bidanada B & Schmidt, T, M, "Delivering continuous manufacturing education and training via an internet-based distributed virtual laboratory," presented at Frontiers in Education conference 2001.
[88] H. L. Huang, C, "Java-based Distance leraning environment for Electronic Instruments," IEEE Transaction on education, vol. Vol 46, pp. 88-94, 2003.
[89] C. C. Ko, B. M. Chen, S. H. Chen, V. Ramakrishnan, R. Chen, S. Y. Hu, and Y. Zhuang, "A web-based virtual laboratory on a frequency modulation experimen," Engineering Science and Education Journal, vol. 9, pp. 69-76, 2000.
[90] D. a. F. Müeller, José, "A mixed-reality learning environment for vocational training in mechatronics," presented at Technology Enhanced Learning International Conference, 2003.
[91] K. Becker, "How Are Games Educational: Learning Theories Embodied in Games," in DiGRA. Vancouver, Canada, 2005.
[92] J. Herrington and P. Standen, "Moving from an Instructivist to a Constructivist Multimedia Learning Environment," Journal of Educational Multimedia and Hypermedia, vol. 9, pp. 195-205, 2000.
[93] L. Galarneau, "The eLearning Edge: Leveraging Interactive Technologies in the Design of Engaging, Effective Learning Experiences," in e-Fest. Wellington, New Zealand, 2004.
[94] D. R. Bielenberg and T. Carpenter-Smith, "Efficacy of story in multimedia training," Journal of Network and Computer Applications, vol. 20, 1997.
[95] Halo2, "Microsoft Game Studios," http://www.halo2.com/, Last visited 30.September.2009.
[96] World of Warcraft, "Blizzard Entertainment," http://www.worldofwarcraft.com/, Last visited 30.September.2009.
[97] C. Bouras, A. Philopoulus, and T. Tsiatsos, "e-learning through distributed virtual environments," Journal of Networking and Computer Applications, vol. 24, 2001.
[98] B. M. Slator, C. Hill, and D. D. Val, "Teaching Computer Science With Virtual Worlds," IEEE Transactions on education, vol. 47, 2004.
[99] ActiveWorlds, "Active Worlds Inc," http://www.activeworlds.com, Last visited 30.September.2009.

[100] Second Life, "Linden Lab," http://secondlife.com/, Last visited 30.September.2009.
[101] M. Csikszentmihalyi and I. Csikszentmihalyi, Beyond boredom and anxiety. San Francisco ,: Jossey-Bass, 1975.
[102] J. Webster, L. K. Trevino, and L. Ryan, "The Dimensionality and Correlates of Flow in Human-Computer Interactions," Computers in Human Behavior, vol. 9, pp. 411-426, 1993.
[103] K. Kiili, "Digital game-based learning: Towards an experiential gaming model.pdf," Internet and Higher Education, vol. 8, pp. 13-24, 2005.
[104] M. Csikszentmihalyi, Flow : the psychology of optimal experience. New York: HarperPerennial, 1990.
[105] J. P. Gee, Why video games are good for your soul: Common ground Publishing, 2005.
[106] C. Aldrich, Learning by Doing : A Comprehensive Guide to Simulations, Computer Games, and Pedagogy in e-Learning and Other Educational Experiences: Pfeiffer, 2005.
[107] D. Freeman, Creating emotion in games: the craft and art of emotioneering. Indianapolis, Ind.: New Riders, 2004.
[108] C. Kolo and T. Baur, "Living a Virtual Life: Social Dynamics of Online Gaming," Game studies, vol. 4, 2004.
[109] T. Manninen, "Interaction Forms and Communicative Actions in Multiplayer Games " Game studies, vol. 3, 2003.
[110] E. Aarseth, "Quest Games as Post-Narrative Discourse," in Narrative across Media: The Johns Hopkins University Press, 2002.
[111] "Wikipedia. Quests in gaming ": http://en.wikipedia.org/wiki/Quest_%28gaming%29.
[112] J. Howard, Quests : design, theory, and history in games and narratives. Wellesley, Mass.: A K Peters, 2008.
[113] v. GNU General Public License: http://www.gnu.org/licenses/old-licenses/gpl-2.0.html, Last visited 11.October.2009.
[114] BioWare, "Neverwinter nights," http://nwn.bioware.com/, Last visited 30.September.2009.
[115] id software: http://www.idsoftware.com, Last visited 30.September.2009.
[116] Doom wad station: http://www.doomwadstation.com/, Last visited 30.September.2009.
[117] Ogre: http://www.ogre3d.org/, Last visited 30.September.2009.
[118] Garage games, "Torque," http://www.garagegames.com/, Last visited 30.September.2009.
[119] Instinct Studius: http://www.instinct-tech.com/, Last visited 30.September.2009.
[120] Torque MMO Kit: http://www.mmoworkshop.com/trac/mom/. Last visited 06.June.2009.
[121] v. GNU Lesser Public License: http://www.gnu.org/licenses/lgpl-2.1.txt, Last visited 11.October.2009.
[122] Sun Microsystems, "Java 3D," http://java.sun.com/javase/technologies/desktop/java3d/, Last visited 30.September.2009.
[123] Java 3D: http://www.java3d.org/, Last visited 30.September.2009.
[124] OpenGL, "Macromedia Dreamweaver," http://www.opengl.org/, Last visited 30.September.2009.

[125] B. G. Davis, Tools for teaching. San Francisco: Jossey-Bass Publishers, 1993.
[126] Python: http://www.python.org/, Last visited 11.October.2009.
[127] L. Hamp-Lyons, "The scope of writing assessment," Assessing writing, vol. 8, pp. 5-16, 2002.
[128] E. Foxley, C. Higgins, P. Symeonidis, and A. Tsintsifas, "The CourseMaster Automated Assessment System – a next generation Ceilidh," presented at Computer Assisted Assessment Workshop, 2001.
[129] E. Foxley, C. Higgins, and A. Tsintsifas, "The Ceilidh System: A general overview," presented at Second Annual Computer Assisted Assessment Conf 1998.
[130] P. W. Foltz, D. Laham, and T. K. Landauer, "Automated essay scoring: Applications to educational technology," presented at EdMedia'99, 1999.
[131] D. Kanejiya, A. Kumary, and S. Prasad, "Automatic evaluation of students answers using syntactically Enhanced LSA," presented at HLT-NAACL03, 2003.
[132] T. K. Landauer, D. Laham, and P. W. Foltz, "The intelligent essay assessor," Ieee Intelligent Systems & Their Applications, vol. 15, pp. 27-31, 2000.
[133] L. S. Larkey, "Automatic essay grading using text categorization techniques.," presented at International Conference of Research and Development in Information Retrieval, 1998.
[134] D. Lonsdale and D. Strong-Krause, "Automated Rating of ESL Essays," presented at HLTNAACL-03 workshop on building natural language processing,, 2003.
[135] M. D. Shermis, H. R. Mzumara, J. Olson, and S. Harrington, "On-line Grading of Student Essays: PEG goes on the World Wide Web," Assessment and Evaluation in Higher Education,, 2001.
[136] R. M. Duwairi, "A framework for the computerized assessment of university student essays," Computers in Human Behavior, vol. 22, pp. 381-388, 2006.
[137] T. Lancaster and F. Culwin, "Using freely available tools to produce a partially automated plagiarism detection process," presented at ASCILITE, Perth, 2004.
[138] T. Lancaster and F. Culwin, "Classification of plagiarism detection engines," Italics e-journal vol. 4, 2005.
[139] M. Shermis and J. C. Burstein, Automated Essay Scoring: Lawrence Erlbaum Associates, 2003.
[140] TurnitIn: http://www.turnitin.com/, Last visited 06.June.2009.
[141] T. Lancaster and F. Culwin, "Towards an error free plagiarism detection process," in ITiCSE 2001, 2001.
[142] The Entertainment Software Association, "Essential Facts About the Computer and Video Game Industry," www.theesa.com/facts/pdfs/ESA_EF_2009.pdf Last visited 30.September.2009.

A Template scripts for the prototypes

A.1 NPC dialogue

```
############################################################
#   Quiz Master Dialog
############################################################
action_Start = DBDialogAction()
action_Start.addCheckNotItem("ITEMNAME")
action_Start.addGiveItem("ITEMNAME")
action_ Start.addTakeItem("ITEMNAME")
action_Start.journalTopic = "TOPIC"
action_Start.journalEntry = "ENTRY"
action_Start.journalText = "TEXT."
action_Start.giveXP = 300
action_Start.giveTin = 10
action_Start.playSound = "sfx/tada.wav"
action_Start.endInteraction = True

choice_Start = DBDialogChoice(text = "TEXT?")
choice_Start.successLine = DBDialogLine(text = "TEXT")
choice_Start.successLine.addAction(action_Start)


action_End = DBDialogAction()
action_End.endInteraction = True

choice_End = DBDialogChoice(text = "Bye")
choice_End.successLine = DBDialogLine(text = "Byeeee !")
choice_End.successLine.addAction(action_End)

dialog = DBDialog()
dialog.name = " DIALOGUE_NAME"
dialog.greeting = DBDialogLine()
dialog.greeting.text = "TEXT"
dialog.greeting.addChoice(choice_Start)
dialog.greeting.addChoice(choice_End)
```

A.2 Recipe for new items

```
r = DBRecipe(name = "NAME")
r.skillname = "SKILLNAME"
r.skillLevel = 3  #Required level of skill
r.craftSound = "sfx/Underwater_Bubbles2.ogg"
r.addIngredient("ITEMTAKEN",2)
r.addIngredient("ITEMTAKEN",1)
r.craftItem = "ITEMGIVEN"
r.costCP = 1
```

A.3 Item description

```
item = DBItemProto(name="NAME")
item.itemType = ['COMMON','COMPONENT']
item.desc = "Descriptive text"
item.stackMax = 5
item.stackDefault = 1
item.worthTin = 1
item.bitmap = "COMPONENTS/Res"
```

A.4 NPC creation and link with spawn point and dialogue

```
############################################################
#   Quiz Master
############################################################
spawn = DBSpawn()
spawn.name = "NAME"
spawn.realm = RPG_REALM_NEUTRAL
spawn.pclass = "Paladin"
spawn.plevel = 20
spawn.sex = "Female"
spawn.race = "Human"
spawn.sclass = "Druid"
spawn.slevel = 18
spawn.tclass="Warrior"
spawn.tlevel = 14
spawn.isMonster = False
spawn.flags=RPG_SPAWN_UNIQUE
spawn.aggroRange=20
spawn.animation="humanoid"
spawn.textureArms="tset_0_arms"
spawn.textureLegs = "tset_0_legs"
spawn.textureBody = "tset_0_body"
spawn.textureHands = "tset_0_hands"
spawn.textureFeet = "tset_0_feet"
spawn.vocalSet='A'
spawn.model="human_female/human_female_fit.dts"
spawn.dialog="DIALOGUE_NAME"
spawn.desc="TEXT."



QM = DBSpawnInfo(spawn=" NAME ")
sg = DBSpawnGroup(zone="questone",groupName="MATHING THE
CREATED POINT IN EDITOR")
sg.addSpawnInfo(QM)
```

B Overview of the scripts and data logged by the systems during game-play

B.1 Getting data from one character database

```
from sqlite3 import dbapi2 as sqlite
import zlib

CHARACTER_TABLES=
["character","character_spell","character_skill","charact
er_advancement","character_dialog_choice","character_vaul
t_item","character_faction","spawn","spawn_skill","spawn_
resistance","spawn_spell","spawn_stat","item","item_conta
iner_content","item_variant","spell_store"]

CURCONN = sqlite.connect("./character.db",isolation_level
= None)
CURCONN.text_factory = lambda x: unicode(x, "utf-8",
"ignore")
cursor = CURCONN.cursor()

cursor.execute("SELECT public_name,character_name,buffer
from character_buffer;")
for name,toon,buffer in cursor.fetchall():
     print "%s with toon %s has these items"%(name,toon)
     dbuffer = zlib.decompress(buffer)
     f = file("./cbuffer","wb")
     f.write(dbuffer)
     f.close()

     PCONN = sqlite.connect("./cbuffer")
     PCONN.text_factory = lambda x: unicode(x, "utf-8",
"ignore")
     pcursor = PCONN.cursor()
     pcursor.execute("SELECT name,stack_count from
item;")
     for item,count in pcursor.fetchall():
          print"     %s %i"%(item,count)
```

B.2 Getting data on player progress in the analogue electronics prototype

```
from sqlite3 import dbapi2 as sqlite
import zlib

CHARACTER_TABLES=
["character","character_spell","character_skill","charact
er_advancement","character_dialog_choice","character_vaul
t_item","character_faction","spawn","spawn_skill","spawn_
resistance","spawn_spell","spawn_stat","item","item_conta
iner_content","item_variant","spell_store"]

NOTCOUNTITEMS = ["Drinking Water","Tasty
Meal","Mobilephone","Pink"]
SPECIALITEMS = ["Voltage divider","Unregulated power
supply","Voltage reference","Voltage divider","DC
Amplifier","AC Amplifier","CE Amplifier","Two transistors
and a resistor","Diff Amplifier","Class B
Amplifier","OpAmp"]
TARGET = ["Phone charger"]

CURCONN = sqlite.connect("./character.db",isolation_level
= None)
CURCONN.text_factory = lambda x: unicode(x, "utf-8",
"ignore")
cursor = CURCONN.cursor()

print "Special items = ",
for i in SPECIALITEMS:
     print "[%s],"%(i),
print ""

print "Target items = ",
for i in TARGET:
     print "[%s],"%(i),
print ""

cursor.execute("SELECT public_name,character_name,buffer
from character_buffer;")
for name,toon,buffer in cursor.fetchall():
     dbuffer = zlib.decompress(buffer)
     f = file("./cbuffer","wb")
     f.write(dbuffer)
     f.close()

     PCONN = sqlite.connect("./cbuffer")
     PCONN.text_factory = lambda x: unicode(x, "utf-8",
"ignore")
```

```
    pcursor = PCONN.cursor()
    pcursor.execute("SELECT name,stack_count from
item;")

    NoOfItems = 0
    Special = 0
    Target = 0
    for item,count in pcursor.fetchall():
        if item not in NOTCOUNTITEMS:
            NoOfItems = NoOfItems + count
        if item in SPECIALITEMS:
            Special = Special + count
        if item in TARGET:
            Target = Target + count

    print "%25s with toon %25s has %3d interresting
items, %3d Special items and %2d target
items"%(name,toon,NoOfItems,Special,Target)
```

B.3 Getting data on player progress from one character database per day in the c++ prototypes

```
import os, glob
from sqlite3 import dbapi2 as sqlite
import zlib

#CHARACTER_TABLES=["character","character_spell","character_skill","c
haracter_advancement","character_dialog_choice","character_vault_item
","character_faction","spawn","spawn_skill","spawn_resistance","spawn
_spell","spawn_stat","item","item_container_content","item_variant","
spell_store"]

InterrestingItems = [['IdentToken',0],['ExpressionToken',0],['key of
Expression',0],['LoopToken',0],['key of
Loops',0],['SelectionToken',0],['key of
Selection',0],['IOToken',0],['key of IO',0],['FunctionToken',0],['key
of Function',0],['ClassToken',0],['NamespaceToken',0],['Mission
complete',0]]

##create the toon list
toonlist = []
CharacterDB =
sqlite.connect("./character/character.db",isolation_level = None)
CharacterDB.text_factory = lambda x: unicode(x, "utf-8", "ignore")
CharDBcursor = CharacterDB.cursor()

CharDBcursor.execute("SELECT public_name,character_name from
character_buffer;")
for name,toon in CharDBcursor.fetchall():
        toonlist = toonlist + [[name,toon]]

##open each character database and select one toon to list from the
toon list
for toon in toonlist:
        print "\n%s with toon: %s"%(toon[0],toon[1])
        print"                                    ",
```

```
        for i in InterrestingItems:
                print"%15s "%(i[0]),
        print ""
        #for infile in glob.glob(
'./character/*/character_backup_*.db' ):
        for infile in glob.glob(
'./character/*/character_backup_1.db' ):
                TmpCharacterDB =
sqlite.connect(infile,isolation_level = None)
                TmpCharacterDB.text_factory = lambda x: unicode(x,
"utf-8", "ignore")
                TmpCharDBcursor = TmpCharacterDB.cursor()
                for i in InterrestingItems:
                        i[1] = 0
                level = 0
                playerXP = 0

                TmpCharDBcursor.execute("SELECT plevel,buffer from
character_buffer
WHERE public_name='%s' and character_name='%s';"%(toon[0],toon[1]))
                for level,buffer in TmpCharDBcursor.fetchall():
                        dbuffer = zlib.decompress(buffer)
                        f = file("./cbuffer.db","wb")
                        f.write(dbuffer)
                        f.close()

                        PCONN = sqlite.connect("./cbuffer.db")
                        PCONN.text_factory = lambda x: unicode(x,
"utf-8", "ignore")
                        pcursor = PCONN.cursor()
                        pcursor.execute("SELECT name,stack_count from
item;")
                        for item,count in pcursor.fetchall():
                                for i in InterrestingItems:
                                        ##print "if i[0] == item:\nif
%s == %s:"%(i[0],item)
                                        if i[0] == item:
                                                i[1] = count

                        pcursor.execute("SELECT id,xp_primary from
character;")
                        for id,xp in pcursor.fetchall():
                                playerXP = xp


                if level == 0:
                        print "%18s %3s: Not created
yet"%(infile[12:infile.find("\character_backup")],infile[infile.find(
"_backup_")+8:infile.find(".db")])
                else:
                        print "%18s %3s: %2s %6s
"%(infile[12:infile.find("\character_backup")],infile[infile.find("_b
ackup_")+8:infile.find(".db")],level,playerXP),
                        for i in InterrestingItems:
                                if i[1] > 0:
                                        print"          %2i
"%(i[1]),
                                else:
                                        print"                ",
                        print ""
```

B.4 Data logged from experiment 5

Of all the participants in the experiment eight have returned to environment after the initial session. More that the eight participant may have logged in after the initial session, but they have not progressed any further in the game, and so they are registered as not to have returned. Of the eight returning participants:

- 1 progressed only on quests that contains the learning material
- 5 participants progressed both on learning material and in the game
- 2 return to play, and did not progress any further in the learning material

Below is a compressed view of the data collected for the 8 returning participants. The information are: Data information is logged, participants Level, experience points (indicating play) Number of tokens (indicated progression n quests) number of keys (indicating completed quests) and if all quest are compiled. Rows with unchanged data from previous date have been removed.

Date	Level	XP	Tokens	Keys	Complete
2009_01_23	1	50	79	4	0
2009_01_25	1	50	79	4	0
2009_01_26	1	50	79	4	0
2009_01_27	1	50	79	4	0
2009_01_28	1	50	134	4	0
2009_01_29	1	50	134	4	0

Date	Level	XP	Tokens	Keys	Complete
2009_01_27	Not created yet				
2009_01_28	4	900	8	1	0
2009_01_29	11	10420	71	3	0
2009_01_30	11	11258	71	3	0
2009_02_01	11	11258	70	3	0
2009_02_02	11	11258	60	4	0
2009_02_03	11	11446	60	4	0
2009_02_04	14	18124	60	4	0

Date	Level	XP	Tokens	Keys	Complete
2009_01_27	Not created yet				
2009_01_28	2	265	46	3	0
2009_01_29	6	3030	14	4	0
2009_01_30	6	2953	36	4	0

Date	Level	XP	Tokens	Keys	Complete
2009_02_02	Not created yet				
2009_02_03	1	63	49	4	0
2009_02_04	4	1075	72	4	0
2009_02_05	4	1075	72	4	0

Date	Level	XP	Tokens	Keys	Complete
2009_01_23	Not created yet				
2009_01_25	1	40	98	4	0
2009_01_28	1	60	86	5	0
2009_01_31	8	5283	96	5	0
2009_02_01	10	10108	96	5	0
2009_02_02	12	13597	96	5	0

Date	Level	XP	Tokens	Keys	Complete
2009_01_27	Not created yet				
2009_01_28	5	2202	8	0	0
2009_01_29	6	3389	7	0	0
2009_01_30	6	3389	7	0	0

Date	Level	XP	Tokens	Keys	Complete
2009_01_27	Not created yet				
2009_01_28	2	265	8	0	0
2009_01_29	3	576	8	0	0
2009_01_30	3	1576	8	0	0

C Questionnaires used for pre and post questioning of the students for all prototypes both in Norway and Scotland

Listed here are all the questionnaires used when gathering information directly from the test subject during the experiments. The forms are shown in their original form, both layout and language. The questionnaires was distributed and handed inn both in paper and/or electronic form during the different experiments.

The forms listed are:

- Pre and post questionnaire for the first experiment described in chapter 5, in English.
- Pre and post questionnaire for the second experiment described in chapter 6, both in English and Norwegian.
- Pre and post questionnaire for the third experiment described in chapter 7, in Norwegian.
- Pre and post questionnaire for the forth experiment described in chapter 8, in Norwegian.
- Pre and post questionnaire for the fifth experiment described in chapter 9 in English.

The Norwegian forms are as close to a direct translation as was possible.

C.1 Initial questionnaire for students testing game for introduction to methods in Java

	Very little	Not much	Average	Quite a lot	Lots
How would you rate your knowledge in programming so far					
How would you rate your knowledge of methods in Java					
How much do you enjoy programming					
Have you any previous experience with computer games					
How much do you enjoy playing computer games					
Have you any previous experience with MMORPG (Massive multiplayer online Role plying Games)					
How much experience do you have with games designed for learning					
How good in your opinion have the games designed for learning you have seen been to play					

In the game there is an option once you have completed all the quests to take on a final assessment. You will be asked to create a narrative using the material presented in the game. This narrative is e-mailed to a tutor and you will receive feedback that can be used as part of your portfolio.

What are your initial thoughts on presenting learning material as a MMORPG game?

What do you want to use as the login name in the game: _____

Thank you for completing this questionnaire. Please hand it to a tutor.

C.2 Questionnaire for students testing game for introduction to methods in Java

What is your login name for the game: _____

Please indicate: Male ☐ Female ☐

	Very little	Not much	Average	Quite a lot	Lots
How would you rate your knowledge of methods in Java after playing the game:					
How much of your knowledge of methods in Java comes from the game:					
The easy was it to navigate trough the learning material in the game					
Did you spend much time initially learning the environment before you could do any learning	0-5 min	5-15 m	15-30m	30-60m	1h ->
How much did other students help you during the game					
How much in your opinion, did the other students enjoy playing the game					
How much did you enjoy playing the game					
How important was the oral introduction to using the game					
How much do you enjoy programming					
If you did the final assessment how difficult did you find it					
If you did the final assessment, how much did you enjoy it					
What are your opinion on games designed for learning changed after trying the game	Hate them	Dislike	OK	Good	Brilliant

Would you like more subject areas to be introduced trough games: Yes ☐ No ☐

What part of the game did you enjoy the most?

Can you suggest any subject areas where a game such as this would fit well?

Thank you for completing this questionnaire. Please hand it to a tutor.

C.3 Initial questionnaire for students testing game for C++

	Very little	Not much	Average	Quite a lot	Lots
How would you rate your knowledge in programming so far					
How much do you enjoy programming					
Have you any previous experience with computer games					
How much do you enjoy playing computer games					
Have you any previous experience with MMORPG (Massive multiplayer online Role plying Games)					
How much experience do you have with games designed for learning					
How good in your opinion have the games designed for learning you have seen been to play					

In the game there is an option once you have completed all the quests to take on a final assessment. You will be asked to create a narrative using the material presented in the game. This narrative is e-mailed to a tutor and you will receive feedback that can be used as part of your portfolio.

What are your initial thoughts on presenting learning material as a MMORPG game?

What do you want to use as the login name in the game: _____

Thank you for completing this questionnaire. Please hand it to a tutor.

C.4 Questionnaire for students testing C++ game

What is your login name for the game: _ _____

Please indicate:

How much time did you spend learning the environment before you could play	0-5 min	5-15 m	15-30m	30-60m	1h ->
Do you feel playing the game improved your knowledge of C++?	Very little	Not much	Average	Quite a lot	Lots
Did the game give you any benefit compared to traditional lecture/lab					
How much did you enjoy playing the game					
How much did other students help you during the game					
Did you have any difficulty navigating the game					
How important was the introduction by the lecturer before playing the game					
If you did the final assessment how difficult did you find it					
Having played the game how useful do you think games like this are for learning					

Which part of the game did you like best?

Which part of the game did you dislike most?

Can you suggest any subject areas where a game such as this would fit well?

Thank you for completing this questionnaire. Please email it to [redacted] or [redacted]

C.5 Initial questionnaire for students testing C++ game version 2

	Very little	Not much	Average	Quite a lot	Lots
How would you rate your knowledge in programming so far					
How much do you enjoy programming					
Have you any previous experience with computer games					
How much do you enjoy playing computer games					
Have you any previous experience with MMORPG (Massive multiplayer online Role plying Games)					
How much experience do you have with games designed for learning					
How good in your opinion have the games designed for learning you have seen been to play					

In the game there is an option once you have completed all the quests to take on a final assessment. You will be asked to create a narrative using the material presented in the game. This narrative is e-mailed to a tutor and you will receive feedback that can be used as part of your portfolio.

What are your initial thoughts on presenting learning material as a MMORPG game?

What do you want to use as the login name in the game: _____
What is your student number: _____

Thank you for completing this questionnaire. Please email it to [redacted] or [redacted]

C.6 Questionnaire for students testing C++ game

What is your login name for the game: _ _____
What is your student number: _____

Please indicate: Male / Female

How much time did you spend learning the environment before you could play	0-5 min	5-15 m	15-30m	30-60m	1h ->
Do you feel playing the game improved your knowledge of C++?	Very little	Not much	Average	Quite a lot	Lots
Did the game give you any benefit compared to traditional lecture/lab					
How much did you enjoy playing the game					
How much did other students help you during the game					
Did you have any difficulty navigating the game					
How important was the introduction by the lecturer before playing the game					
If you did the final assessment how difficult did you find it					
Having played the game how useful do you think games like this are for learning					

Which part of the game did you like best?

Which part of the game did you dislike most?

Can you suggest any subject areas where a game such as this would fit well?

Thank you for completing this questionnaire. Please email it to [redacted] or [redacted]

C.7 Introduksjonsspørsmål for C++ spill

	Veldig lite	Lite	Middels	Mye	Veldig Mye
Hvor mye kan du om programmering					
Hvor mye liker du å programmere					
Har du tidligere spilt dataspill					
Hvor mye liker du å spille dataspill					
Har du tidligere spilt MORPG (Multiplayer online Role playing Games)					
Hvor mye erfaring har du med spill laget for lærling					
Hvor mye likte du de spillene laget for læring som du har spilt					

I spillet er det en ekstra mulighet dersom du fullfører spillet. Dersom du gjennomfører denne oppgaven og sender den inn vil du få tilbakemelding.

Har du noen initiale tanker rundt det å presentere læringsmateriale som et MMORPG spill?

Hvilket login navn har du tenkt å bruke I spillet: _____

Takk for at du deltar, og for at du svarte på dette skjemaet. Vennligst gi det til Olaf Hallan Graven når du har fylt det ut.

C.8 Spørreskjema C++ spill

Hva var ditt login navn: _____

Føler du at du er: Mann ☐ eller dame ☐

Hva lang tid bruke du før du kunne spille spillet?	0-5 min	5-15 m	15-30m	30-60m	1h ->
Hvor mye bedre er du til å programmere etter å ha spilt spillet?	Ingenting/ Veldig lite	Lite	Middels	Mye	Veldig mye
Hvilket utbytte fikk du av å spille i forhold til vanlig øvning					
Hvor mye likte du å spille spillet					
Hvor mye hjelp fikk du av medspiller I selve spillet					
Hvor store probelmer ahdde du med å navigere i spillet					
Hvor viktig var introduksjonen som ble gitt til spillet					
Dersom du kom til siste delen (inne i byggningen- the great hall) Hvor vanskelig var det					
Etter å ha testet spillet, hvor nyttig tror du slike spill er for læring					

Hvilken del av spillet likte du best?

Hvilken del av spillet likte du minst?

Forsøag, forbedringer, eller andre fagområder som kan egne seg:

Takk for at du svarr på dette. Send det til [redacted] eller legg det I hylla til Olaf eller Hans.

C.9 Introduksjonsspørsmål for analog elektronikk spill

	Veldig lite	Lite	Middels	Mye	Veldig Mye
Hvor mye kan du om strømforsyninger i analog elektronikk					
Hvor mye liker du å jobbe med analog elektronikk					
Har du tidligere spilt dataspill					
Hvor mye liker du å spille dataspill					
Har du tidligere spilt MORPG (Multiplayer online Role playing Games)					
Hvor mye erfaring har du med spill laget for lærling					
Hvor mye likte du de spillene laget for læring som du har spilt					

Har du noen initiale tanker rundt det å presentere læringsmateriale som et MMORPG spill?

Hvilket login navn har du tenkt å bruke i spillet: _____

Takk for at du deltar, og for at du svarte på dette skjemaet. Vennligst gi det til Olaf Hallan Graven når du har fylt det ut.

C.10 Spørreskjema etter spill

Hva var ditt login navn: _____

Hvilket login navn skrev du på det første skjemaet _____
(Oppgis bare dersom det var et annet)

Føler du at du er: Mann/Gutt ☐ eller Dame/Jente ☐

Hva lang tid brukte du før du kunne spille spillet?	0-5 min	5-15 m	15-30m	30-60m	1h ->
Hvor mye bedre oversikt har du over strømforsyninger har du etter å ha spilt spillet?	Ingenting/ Veldig lite	Lite	Middels	Mye	Veldig mye
Hvilket utbytte fikk du av å spille i forhold til vanlig øving					
Hvor mye likte du å spille spillet					
Hvor mye hjelp fikk du av medspiller I selve spillet					
Hvor store problemer hadde du med å navigere i spillet					
Hvor viktig var introduksjonen som ble gitt til spillet					
Etter å ha testet spillet, hvor nyttig tror du slike spill er for læring					

Hvilken del av spillet likte du best?

Hvilken del av spillet likte du minst?

Forslag, forbedringer, eller andre fagområder som kan egne seg:

Takk for at du svarer på dette. Send det til [redacted] eller legg det i hylla til Olaf eller Dag.

C.11 Test av nettverk "spill" før du starter

	Ingen	Lite	Verken/eller	Mye	Veldig mye
Have you any previous experience with computer games					
How much do you enjoy playing computer games					
Have you any previous experience with MORPG (Multiplayer online Role plying Games)					
How much experience do you have with games designed for learning					
How good in your opinion have the games designed for learning you have seen been to play					

What are your initial thoughts on presenting learning material as a MORPG game?

What do you want to use as the login name in the game: _____

C.12 Test av nettverk "spill" etter spillet

Please indicate: Male ☐ Female ☐

How much time did you spend learning the environment before you could play	0-5 min	5-15 m	15-30m	30-60m	1h ->
Do you feel playing the game improved your knowledge of nettworking	Very little	Not much	Average	Quite a lot	Lots
Did the game give you any benefit compared to traditional lecture/lab					
How much did you enjoy playing the game					
How much did other students help you during the game					
Did you have any difficulty navigating the game elements (Not the maze)					
How important was the introduction by the lecturer before playing the game					
Having played the game how useful do you think games like this are for learning					

Which part of the game did you like best?

Which part of the game did you dislike most?

Can you suggest any subject areas where a game such as this would fit well?

Thank you for completing this questionnaire. Please email it to [redacted]

C.13 Initial questionnaire for students testing C++ game

	Very little	Not much	Average	Quite a lot	Lots
How would you rate your knowledge in programming so far					
How much do you enjoy programming					
Have you any previous experience with computer games					
How much do you enjoy playing computer games					
Have you any previous experience with MMORPG (Massive multiplayer online Role plying Games)					
How much experience do you have with games designed for learning					
How good in your opinion have the games designed for learning you have seen been to play					

In the game there is an option once you have completed all the quests to take on a final assessment. You will be asked to create a narrative using the material presented in the game. This narrative is e-mailed to a tutor and you will receive feedback that can be used as part of your portfolio.

What are your initial thoughts on presenting learning material as a MMORPG game?

What do you want to use as the login name in the game: _____

What is your student number: _____

Please indicate: Male / Female

C.14 Questionnaire for students testing C++ game

How much time did you spend learning the environment before you could play	0-5 min	5-15 m	15-30m	30-60m	1h ->
Do you feel playing the game improved your knowledge of C++?	Very little	Not much	Average	Quite a lot	Lots
Did the game give you any benefit compared to traditional lecture/lab					
How much did you enjoy playing the game					
How much did other students help you during the game					
Did you have any difficulty navigating the game					
How important was the introduction by the lecturer before playing the game					
If you did the final assessment how difficult did you find it					
Having played the game how useful do you think games like this are for learning					

Which part of the game did you like best?

Which part of the game did you dislike most?

Can you suggest any subject areas where a game such as this would fit well?

Thank you for completing this questionnaire.